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An Illustrated Weekly Journal

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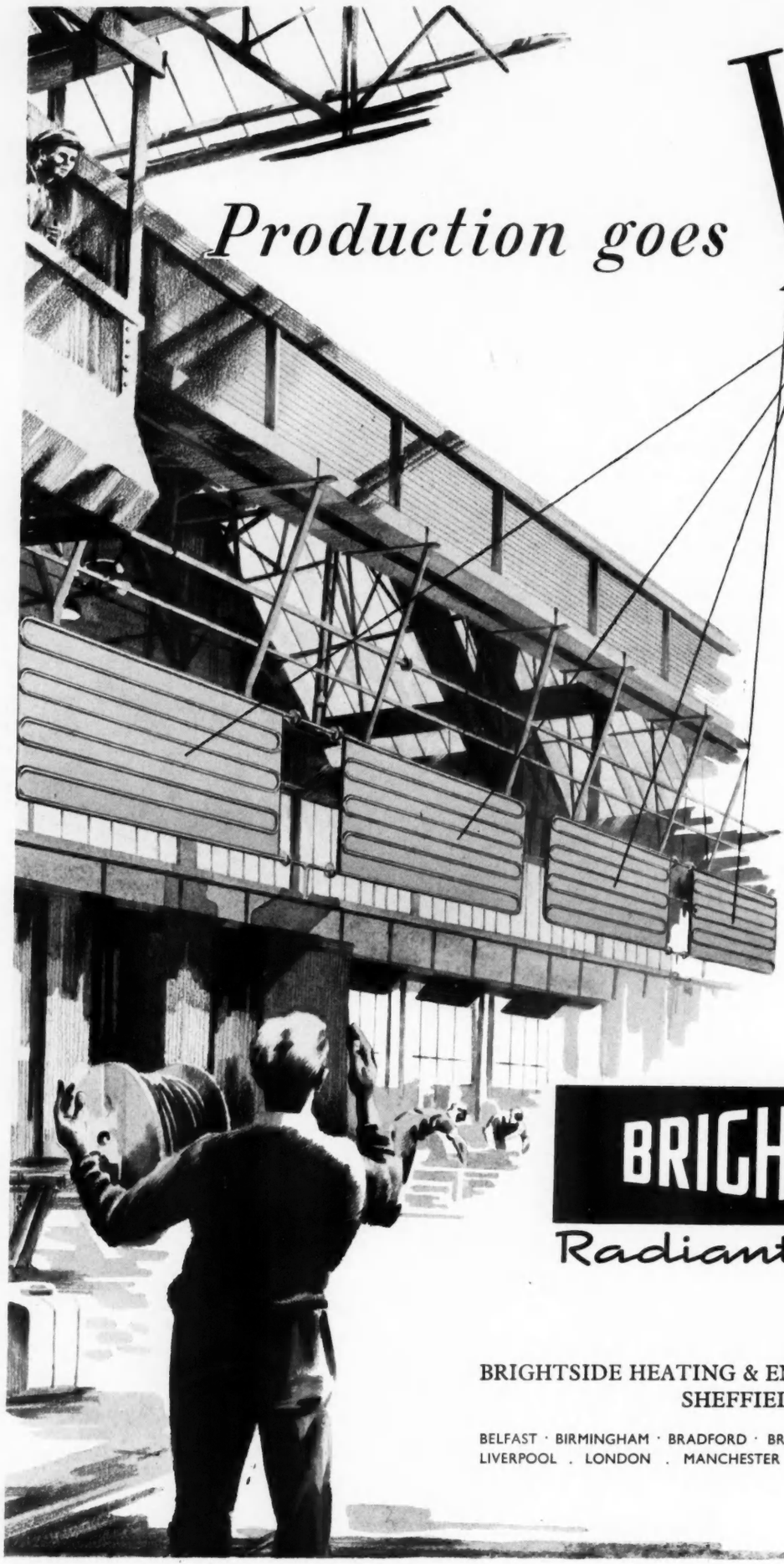

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THE CENTURY OF WHAT?

IN the first issue of this journal for the year 1901 a leading article quoted some remarks of Dr. Ludwig Mond at a meeting of the Institution of Mechanical Engineers held in the closing weeks of 1900. "We are," he is recorded as saying, "now closing the century of steam, and opening the century of power-gas." To-day, the developments which have actually taken place are so different from those envisaged by the eminent Dr. Mond that we have to think twice to know what he meant by "power-gas." Experience of the unpredictable has warned us that it is foolish to predict that there is no future in even the most academic ideas. But perhaps we have fallen into an error of a different kind—that of being wildly optimistic about the fashionable and latest developments, such as atomic energy, and rather cynical about the unexciting ideas, such as wind power, solar energy, tidal power, or peat as a fuel for industry.

A brief review of the less common forms of power is given elsewhere in this issue. In most cases they are at present only of local interest—peat in Ireland, tidal power in France, solar energy in tropical countries—and in most cases, too, they are only marginally attractive from an economic point of view. Considerable work has been done on the utilisation of wind power, particularly in Britain, but the obvious difficulty inherent in wind power—its variable nature and the associated difficulty of storing electrical energy—appears to rule it out except for special purposes. The position with solar energy is rather similar. It is variable and the capital cost of the plant more than offsets the apparent saving in fuel. Tidal power, also, is variable, though French engineers are hopeful that economic use will be made of it. The sun, the wind and the tides are, however, inexhaustible. Unlike coal, oil and other similar fuels, the power that can be derived from them will not decline. When Man has scraped the bottom of the barrel for oil, and there is no coal to be mined at any price, the energy of the universe will presumably still be available. That situation is far enough away to be of no personal significance to us at the present time, but long before it is reached the pattern of power engineering and economics will change. Every year the relative values change almost imperceptibly. That is why it is so unwise to maintain that any one form of power has no future. A vigilant attitude towards all forms of power is essential. And not only to power but to every engineering scheme which shows some promise.

A glance at engineering developments during the past year is sufficient to show that, however static the science appears to an individual engaged in one specialised field, there are many growing points which show up even in so short a period as twelve months. Taking technical developments first, there has been some encouraging work on the continuous casting of mild-steel billets. The new "Cyclosteel" process for reducing iron ore—in which droplets of the liquid ore are distributed in a high-temperature reducing gas—has reached the stage where it is hoped that within ten years this type of steel will be in general use. Developments in atomic energy—particularly British achievements—need no repetition; but it is worth noting that countries which are quite small from an industrial point of view are beginning to cash in on British and American pioneer work by purchasing equipment from the leading manufacturers, and by getting advanced engineers and scientists to come to their universities to work on research and teaching.

In designing conventional power stations the chief developments have been the ever-increasing size of turbo-alternators and the continued raising of steam pressures and temperatures. Railway engineering, as in the past, seems to hold out many exciting possibilities but not so many actualities. The successful development of germanium rectifiers has amended the details of policy on electrification, but in Britain, at least, there is not the same national urgency on railway improvement that is found in other branches of engineering. Gas-turbine motor cars seem to be nearer the practical production stage, as is shown by an article in this issue. Electronic computers are being applied remarkably quickly to design and commercial problems—in fact, we might take the risk that Dr. Mond took and express the belief that the application of computers will transform the practice of engineering, and probably management also, in the next generation.

In the broad international field of affairs, in so far as they touch on engineering, the year 1956 has been exceptional because the Suez trouble has not encouraged the increasing readiness of the industrial countries to lend help to the awakening under-developed countries. The under-developed countries themselves have still to learn the diplomacy and art of accepting help with a good grace.

Events have proved Dr. Mond to have been rather optimistic about the role of power-gas in engineering, but he was certainly right to take a forward look. To look up from the desk or the drawing board and peer into future possibilities is not so much a duty as the instinctive tendency of every engineer—

and a tendency which breeds the developments of the future. If the performance of the leading British engineering industries during the past decade is anything to go by, there are solid grounds for holding that 1957 will witness further developments the nature of which is hardly known except to those few who are working on new ideas. The Twentieth Century is more than half over—surely we can say what it is the century of? Just because the answer appears to be so obvious we will resist the temptation to give it. The "power-gas" of the present generation may yet be ousted by the brain-child of one of those engineers who are patiently working on seemingly forlorn projects. Good luck to them.

* * *

Plain Words

In addition to their obvious capacity to compete successfully in shipbuilding and general engineering, as well as in high-quality textile goods, the Japanese are showing signs of increasing participation in overseas subsidiaries. The amounts of capital investment involved may not look very impressive as yet but they represent the spearhead of powerful organisations which will in due course rapidly expand their activities in these countries once they have secured a foothold.

Since the recovery of Japanese industry after the war the Japanese have invested 21 million dols. in 96 overseas sales offices and 41 partly or wholly owned manufacturing subsidiaries in 23 countries. Of the sales branches, 58 are in the United States, 8 are in Brazil, 4 are in Argentina and the rest are scattered throughout the world. It would be expected, in the circumstances of Japan's recovery, that the first major effort overseas would be in the U.S. market, but there is clear evidence of growth in South America. The manufacturing subsidiaries are concentrated mainly in Latin America and in South East Asia. The investments in Latin America are fewer in number than those in South East Asia but their total value is greater. The pattern in South East Asia is mainly of light industries or mining developments where a small initial capital outlay is all that is required. So far as joint enterprises are concerned, most progress has been made by trading technical advice and capital equipment for participation in ownership. There is still some prejudice against Japanese control in parts of South East Asia and infiltration by technical advice has thus been the main means of developing Japanese overseas interests.

The scarcity of good technical and managerial staff in under-developed areas is, in fact, putting such a premium on their services that no country can be sure of getting a significant share in the trade with such areas unless it can supply technicians as well as capital. Business and long-term goodwill in underdeveloped areas are likely to go to countries which provide experienced men rather than to those which provide the capital.

Fig. 1 Turbine car fitting shop in the Rover experimental department. In the foreground is the T3 coupé with plastic body seen at the Motor Show.

BRITAIN COULD BE FIRST with a saleable TURBINE CAR

By Gordon Wilkins

Published statements regarding the possibility of producing gas-turbine cars for sale to the public are usually vague and cautious, and the recent remarks of Dr. F. Llewellyn Smith, managing director of the Rolls-Royce car division, are no exception. He is reported as saying that he would be very surprised to see gas turbines in many cars even by 1976. But he reserved the right to change his mind at any time. Some engineers with whom I have talked believe that Britain could be the first country to market a gas turbine car, and in the not very distant future. During the present difficult period several factories are pressing on at full speed with turbine development and are making steady progress. The personnel engaged refuse to be over-awed by the immense resources which the American industry can devote to gas turbine research. A large part of this effort has to be devoted to finding ways of making very cheap turbines, as the American manufacturer expects to make his complete power unit for a few dollars. Unless the price is right, there is no point in contemplating production. In the European specialist car field, it should be possible to make a commercial proposition of a turbine car with an engine costing several times as much as the Americans can afford to pay. British engineers are therefore concentrating their efforts on making efficient turbines, leaving the question of cheap mass production for later consideration.

The Rover T3, the blue plastic-bodied turbine coupé which was exhibited at the London Motor Show and may be seen in Fig. 1, will shortly be running with an improved power unit which should show a useful improvement over the performances obtained in the autumn. A lash-up car with light-alloy body, which was used to try out the power unit and suspension system of the T3, is illustrated in Fig. 2. The original engine, with single-stage centrifugal compressor driven by a single-stage turbine, followed by a single-stage power turbine, developed 110 b.h.p. at 52,000 compressor r.p.m., with a pressure ratio of 3·85 to 1. The turbine is shown in position in Fig. 3. The car accelerated from 0 to 60 m.p.h. in 10½ sec., and 0 to 80 m.p.h. in 18 sec. and showed a fuel consumption of 14·3 miles per Imp. gal. (19·6 lit. per 100 km.) at 60 m.p.h.

The new unit has improved ducting to raise the efficiency of the heat exchanger, and has a new compressor turbine, in Nimonic 100 instead of Nimonic 90, which is of improved design and able to tolerate a higher gas temperature. It is considered that this should show fuel consump-

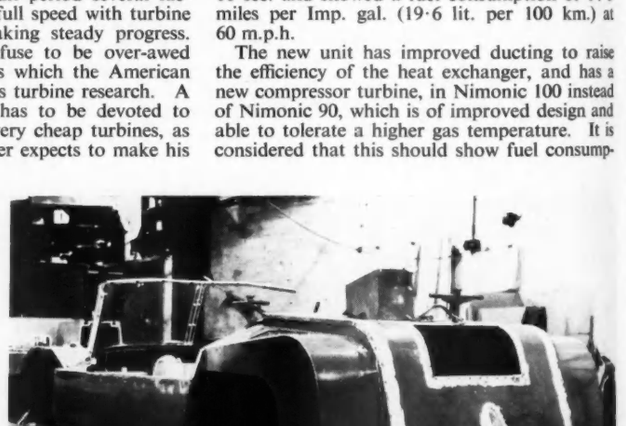

Fig. 2 A turbine car which has not been seen by the public: a "lash-up" car with light-alloy body, which was used to try out the power unit and suspension system of the T3 at the M.I.R.A. proving ground while the show car was being built.

Fig. 3 Turbine in the rear of Rover T3. Air enters two intakes on top of the rear wings, and passes through large air filters and silencers in the rear wings. It is conveyed to the compressor through two ducts, which appear at the bottom of the illustration. The top of the combustion chamber is seen at the right, and the exhaust emerges from the heat exchanger at top centre.

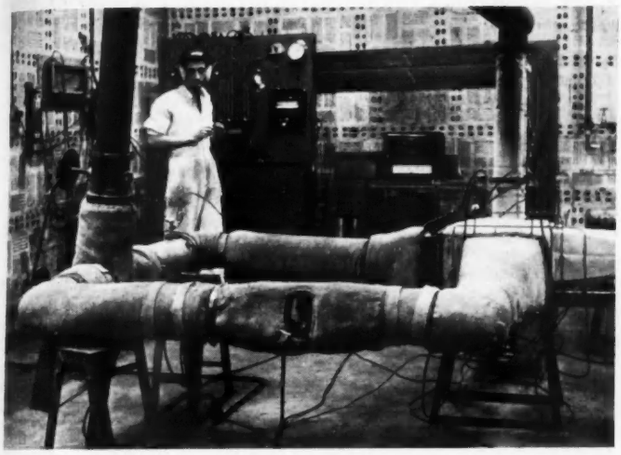

Fig. 4 Heat exchanger test rig at Austin's. Air enters at right, passes through a matrix, then through the combustion chamber, and back through the heat exchanger. Manometers plot the pressure pattern.

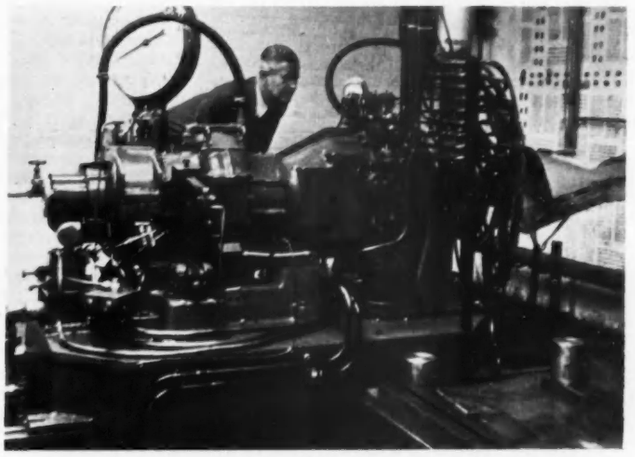

Fig. 5 30 h.p. turbine on a dynamometer at the Austin works.

tions around 17 m.p.g. (16·6 lit. per 100 km.).

Given supplies of 95-100 octane fuel, British piston engines will soon be running at compression ratios of 10 to 1, and the gas-turbine engineer has to assume that by the time his power unit is ready for production, it will have to compete against piston engines far more efficient than those now in use, but Mr. Spencer King, engineer in charge of gas-turbine development at Rover told me: "If we could combine in one unit components giving the efficiency now obtained separately on test rigs, we should already have a strong competitor to the piston engine."

Rover and Austin are at present concentrating on the development of the static secondary surface heat exchanger. In the United States high efficiencies have been reported in rig tests of rotary recuperators, but the problem of sealing the moving faces is regarded as extremely difficult and the static type is thought to offer better possibilities for early development into a practical saleable unit. At present the heat exchanger is very heavy; the Rover unit weighs 110 lb., and the Austin probably not less. The material used is stainless steel, which is costly, and materials alone might cost £60.

However, the weight is not an insuperable disadvantage, because the rest of the power unit is so light. For example, the whole rear-end assembly on the Rover T3, comprising compressor, heat exchanger, combustion chamber, turbines, reduction gear, differential and disc brakes, weighs about 430 lb. This compares favourably with the weight of a 110 h.p. piston engine, with automatic transmission, and back axle. At present there is a further item of about 40 lb. for the asbestos heat insulation surrounding the engine compartment, but this should be reduced as engine efficiency is improved.

Before embarking on large-scale production it would be an advantage to gain extensive operating experience with a number of cars in various operating conditions. This might be done by selling a small series of cars to selected customers, such as garage proprietors and experienced competition drivers.

At Rovers, a life of 1,000 hours between overhauls is already regarded as assured. This would mean 35,000 to 50,000 miles, according to operating speeds. The limiting factor is the building up of deposits of oil and dirt on the compressor blades, which rapidly reduces efficiency. In current experimental units this entails a major dismantling operation, comparable with decarbonising early piston engines which had non-detachable cylinder heads. An engine designed for production would include provision for easy access to the compressor, and cleaning would then be much simpler and quicker than decarbonising a modern piston engine.

Rovers are also using the T3 car as a means of developing four-wheel drive and new types of suspension. Four-wheel drive is regarded as a valuable asset for a light powerful car. Design has progressed far beyond that of the Land Rovers, where the primary aim was traction on cross-country work. Four-wheel drive, properly adapted, is proving a big asset in main-road acceleration, and high-speed cornering. Both front and rear suspensions on the Rover work on the principle of using the drive shaft as a suspension member. At the front it forms one arm of the lower wishbone for a coil-spring suspension unit. At the rear, the drive shafts locate the De Dion axle with the aid of Watt linkages at the hubs. This causes slight variations of track with wheel deflection, which are accommodated by a sliding joint in the axle tube.

At the Austin works at Longbridge, the turbine section of the research department now occupies an important area, with sound-proofed remote-control dynamometer for the testing of complete power units, and separate rigs for the development and testing of compressors, heat exchangers and other components. A heat exchanger test rig appears in Fig. 4. The 120 h.p. engine of the original Sheerline turbine saloon, with two-stage compressor and three-stage compressor turbine, is being further developed with a static-type heat exchanger. The smallest unit on test is a turbine under development for the Ministry of Supply, giving 30 h.p. at 56,000 r.p.m., a size which would suit the small family car of the future. A special dynamometer has been developed for it, swinging in oil, to eliminate friction, as the total brake loads involved are under 10 lb. The 30 h.p. unit is shown under test on the dynamometer in Fig. 5. Parts of the

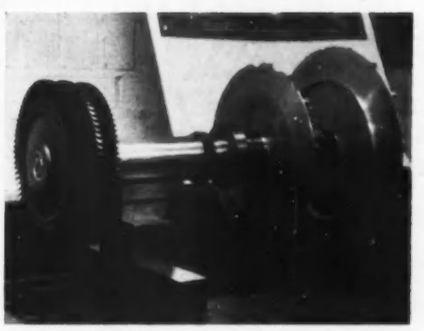

Fig. 6 Two-stage compressor and three-stage compressor turbine rotors of Austin 120 h.p. unit.

larger turbine, the Austin experimental 120 h.p. engine, are seen in Fig. 6.

The ability of the gas turbine to use a wide variety of cheap fuels is unlikely to bring any great benefit to car owners. Fuel must be readily available at the roadside, so there is good reason for using something already on sale at filling stations. Moreover, it is assumed that if any very cheap fuel were used, taxes would soon be imposed to cancel out the advantage. Rovers are using Diesel oil. The sulphur content has produced small quantities of sulphuric acid in the exhaust, which have attacked the joints of the heat exchanger, but this is not a serious problem. Progress in heat-exchanger design should soon enable the height of the rear deck on the T3 coupé to be reduced, which would make it a really good-looking car.

Weekly Survey

Cover Picture: *During the process of drop forging, some lubricant has to be applied to the die. The illustration shows such an application being made during the forging of a jet-engine turbine disc.*

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Common Endeavour

A report by a European inter-governmental committee presided over by Mr. Paul-Henri Spaak, the Belgium foreign minister, dealing with three major issues for western Europe: the Common Market, "Euratom" and the integration of fuel and power, air transport, postal and telecommunications services was presented several weeks ago. A summarised translation of the first part, on the Common Market, was published last week by P.E.P. on the grounds that it is of considerable importance and far too little known in this country.

P.E.P.'s broadsheet sets out in detail the advantages of economic integration and considers the problems which will have to be solved as integration proceeds. The proposal for a free trade area is rejected in favour of a common market with a unified external tariff. In a free trade area each country is allowed to fix its own tariff to countries outside the area. The Spaak report argues that this would be impossible in practice, since goods could be imported into the area though the country with the lowest external tariff and resold within it to a country whose external tariff was higher, thus nullifying the tariff differences.

The report points out that the revolutionary changes envisaged in trading patterns, with their inevitable repercussions on industrial structures within each country, cannot be made overnight: a transitional period of twelve to fifteen years is envisaged. After the first year of a Common Market Treaty, there would be a 10 per cent. overall cut on all tariffs. Following the first cut, there would be two further overall reductions of 10 per cent. at intervals of eighteen months, making 30 per cent. in all for the first four-year period. For the second stage, the process would be the same, making a 60 per cent. reduction on the first eight years. In the final four years the remaining 40 per cent. would be eliminated.

Safeguards are considered necessary to prevent individual hardship and the automatic working of the Common market must be corrected and supplemented by rules and common actions to ensure the most rational division of labour, the most effective economic expansion, and the raising of the standard of living. Competition must be maintained, and the distortions which favour or handicap certain industries must be corrected. These include the results of direct or indirect taxation; the financing of social security; certain price regulations; working conditions, such as equal or unequal pay for men and women, working hours, overtime, and paid holidays; different credit policies. The special problems of agriculture, of the balance of payments and related subjects are examined. Finally the report proposes the establishment of two common funds: an investment fund to provide the necessary capital for the economic development of the Common Market and a re-adaptation fund to prevent hardship and ensure that displaced labour is resettled or retrained.

Inevitably, Britain's economic position will be profoundly affected if the proposals embodied in this report are put into practice. It is the major economic issue of the post-war era.

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Common Danger

The two giants of the Twentieth Century have founded their strength on the union of different States. In both cases there is economic union: free trade within the whole area, and political union: a federal government in which the "governments" of the constituent States are represented. Both the United States of America and the Union of Soviet Socialist Republics constitute a vast free-trading area within which industry has grown up to the full size of the total market. But both began the process of large-scale industrialisation with this advantage of economic and political unity. There lies the essential difference between them and the countries of Europe. The latter, including Britain, became industrialised at a time when the known methods of production and trading practices suited smaller-scale endeavour. When the technological advances came about which make it possible to produce more efficiently on a very large scale (as is the case in motor manufacturing and many other "mass market" industries) and when immense resources become necessary to finance and implement the research and development necessary to maintain the rate of technological advance, European countries were too small individually to take advantage of either. Another important difference is that the two giant nations are, in relative terms, virgin lands with immense natural resources; Europe has to import fuel, food and much of the materials its industries require. Gradually the United States, and to a lesser extent the U.S.S.R., are being forced to import materials also, but the fact that their industries are based on a mass market for standard products will enable them to compete strongly for available world resources.

There is a growing realisation in Western Europe and in this country that traditional sources of raw materials can no longer be looked upon as secure. Political control has for the most part gone, or is going fast. Also, that if economic and political unity cannot be furthered to bring about an increase in industrial efficiency, through the fostering of larger scale and more specialised production, the rate of saving possible on a national scale will be too low either to sustain the research, education, training and investment to keep abreast of technical change, or to invest in the development of the natural resources available in countries with little manufacturing industry but abundant natural resources.

Such is the background of the proposals for a common market in Europe, for a European atomic energy pool ("Euratom"), and for other measures to integrate the economics of Western Europe into a unit large enough to warrant the use of the most efficient methods of production and rich enough to secure its needs of raw materials by investment in their development and by being in a position to pay competitive prices.

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Higher Steel Prices

Since December 17, the maximum prices of iron and steel products have been raised, on the average, by about 6 per cent. The Iron and Steel Board have been carrying out a review of the industry's price structure for some time and the change came as no surprise. The new price schedule takes no account of the Suez crisis and the Iron and Steel Board have made it quite clear that a review of the industry's cost and price position will have to be made in due course when the effects of the international situation have had time to work themselves out on trading experience.

These price alterations reflect both an increase in costs of production and an adjustment of profit margins. Imported materials, inland-transport charges, coal and wages have all increased in price since the Spring of 1956. The new increases have been designed to cover these additional charges in operating costs and also to provide gross-profit margins which will enable the industry to make some provision for the capital requirements of the future. On recent past experience, the industry aims to provide about half the capital required for development out of its own resources, leaving the balance to be provided by the open capital market. It follows from this that the average increase of 6 per cent. hides some marked differences between products. The prices of plates, heavy sections and some foundry pig-iron products, have increased more than others since more finance is likely to be required to provide additional capacity for those products than for most others in the industry.

It is expected that the new prices will be, on the average, about 8 per cent. below those in Western Europe. The margin between British and Continental prices is thus narrowing although the advantage remains with this country. While advances in steel prices are not welcome to the engineering industry, the decision by the Iron and Steel Board not to be deterred in their development programme by current international problems is welcome. If the European common market becomes a reality, one of this country's main hopes of expansion would be the competitive power of its modern and highly capitalised steel industry.

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Norwegian Steel Problems

The announcement, some weeks ago, that the project for establishing a seamless-tube mill in Norway has been postponed, is an interesting example of the problems which beset those who seek foreign capital to develop basic industries. Norsk Jernverk has been one of those projects which, despite political vicissitudes, has in the end been an attractive project both to a Socialist Government in Norway and to private enterprise. The decision to enter the field of seamless tubes by installing a tube mill having an annual capacity of 60,000 tons was taken after careful consideration of the technical and commercial risks involved. It was decided that the commercial prospects for such a mill were good, although the technical hazards were considerable.

A key to the entire project was Dutch finance. Here again the basis of an arrangement could be readily found. From the official Norwegian point of view, there was a prospect of Dutch gilders and from the long-term Dutch point of view there was the possibility that the loss of its Indonesian interests might in time be partially replaced by a greater participation in the economic development of Scandinavia. The Dutch have, in fact, shown every sign of competing systematically and successfully against the British and the Germans in many fields in this area.

The demands on capital resources within the Netherlands, however, made it impossible for the Dutch Government to approve the transfer of the necessary capital. In consequence, the tube mill remains a paper project, albeit an attractive one. It is apparent from this case history that other countries besides the United Kingdom have a problem of spreading limited capital resources over a wide range of interesting projects both at home and abroad, especially as the home projects include an unavoidable large and continuing programme of social capital expenditure. The Norsk Jernverk project, however, also draws attention to a fact which has become increasingly apparent and of growing importance to British exporters, namely, that our Continental competitors are prepared, whenever they can, to tackle their export problems systematically and imaginatively. There are many devices which exporting organisations with adequate working capital can find to help in the development of capital-starved countries besides investing formally in individual projects. It is important that British industry should find similar devices and put them into practice as quickly as possible.

Cleaner Coal

The drive for cleaner coal by the National Coal Board has progressed far since the war. Over the past ten years 200 preparation plants capable of treating 68 million tons of coal a year, together with 107 froth-flotation plants for cleaning coal in a very fine form, have been installed at a cost of some £40 million. In addition, another 40 plants with a capacity of 26 million tons a year and costing nearly £19 million are under construction or are being designed. The Board are seeking to reduce the amount of hand-cleaned coal and are up against the problem of more and more dirt being mined due to coal-getting becoming more mechanised and to the working of thinner seams.

The 200th preparation plant, with a capacity of 400 tons an hour, was commissioned last week at Cwm Colliery, South Wales. This is not particularly large by modern standards: the largest, at Manvers Main Colliery, has a capacity of 1,320 tons an hour and there are several treating coal at rates ranging from 600 to 800 tons an hour. Considerable progress has been made in recent years in coal-cleaning techniques, particularly in the froth-flotation method whereby coal particles coated with special oil (mixed with the fine coal and water) attract tiny air bubbles introduced into the mixture and are carried to the surface to be raked off in a froth. This method is now used for coal up to $\frac{1}{16}$ in. in size, whereas particles of this size were formerly considered too heavy to be lifted by air bubbles. At Cwm, a Frazer and Chalmers "Mineral Separation" froth-flotation process is used for coal up to $\frac{1}{16}$ in. in size. Bigger coal is cleaned by the "Chance" sand-flotation process.

The Cwm washing plant operates as two separate units each of 200 tons an hour capacity, in order to keep entirely separate the two qualities of coal, a high sulphur and a low sulphur content, in order to produce a correct blend of the two for use in the manufacture of metallurgical coke. The plant is largely automatic and therefore most economical of manpower. In this manner the N.C.B. are more than matching on the surface the savings in men being effected by the intensive mechanisation of coal cutting and handling below ground. The quantity of coal cleaned by hand has been reduced from 87 million tons in 1946 to 47 million tons in 1955, despite an increase of 16 per cent. in the mined output.

★ ★ ★

Coal Gasification Activity

Sir Alexander Gibb and Partners have been appointed by the National Coal Board to act as consultants in association with Cremer and Brearely on underground gasification. Humphreys and Glasgow have been appointed the main contractors for the engineering and scientific work and it is expected that a pilot scheme will be in operation by the end of 1958. There has thus been a sudden increased activity in a subject which in the past has endured many experiments but little commercial progress. It has long been known that gasification was technically possible but the cost of the gas has been uneconomic for the problems of underground gasification, though not particularly involved, do not lend themselves to elegant solutions.

Thanks to inflation, however, the economic picture has been changing of late. The average cost of coal, including handling, used by the British Electricity Authority in the financial year 1954/55 was 3·4*d.* per therm and has since increased. The cost of imported fuel is as high as 6*d.* per therm and estimates of costs from coal gasification are at rather less than 3*d.* per therm. The National Coal Board has estimated that there are at least 300,000 tons of coal in uneconomic seams and a significant proportion of this tonnage could probably be raised by gasification if estimated operating costs proved to be correct. The coal seam chosen for gasification at Newman Spinney is of secondary quality and not worth mining because of its high ash content.

If the pilot plant is successful a 60,000 kW power station is likely to be built, using about 1,000 tons of coal a day. Humphreys and Glasgow have said that they also hope to develop methods of making synthesis gas for conversion into other products, including oil fuels.

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The Reliable Diesel

For all those who are concerned with the operation or maintenance of heavy oil engines, the annual "Report on Heavy Oil Engine Working Costs and Performance" presented to the Diesel Engineers and Users Association on December 20, 1956, makes very interesting reading. Although the first section of it is devoted to notes and comments on troubles experienced, the overall picture is one of complete reliability. Reports were received from 92 different sources and have been analysed for running costs and for load factor and availability.

In the notes and comments received from members are such remarks as "The same engine has had its first overhaul at 10,000 hours," "A new crankshaft with main and big-end bearings was fitted to one of the 1,100 b.h.p. 360 r.p.m. engines which had run for 49,000 hours since installation," "The metal-sprayed pistons in one of the engines have been in service for over 14,000 hours and continued to operate satisfactorily," "The engine operates continuously for 4,000 hours during the winter months under automatic control of temperature and shutting down in the event of various types of failure. The low rate of wear of the liners of 0·0003 in. per 1,000 hours is attributed to continuous operation under close automatic control," "The working hours to date range from 17,215 to 88,376."

Surely such figures as these prove that the Diesel engine has now reached the stage when it can truly be classed as almost in the "fit and forget" category. Still, the notes and comments do bring out some points that can well receive more attention, but these are mainly within the province of the user rather than the manufacturer. The advantages of detergent and additive oils are again brought to the fore, and so are those of exact temperature control and proper filtering of the air intake. The reports come from stations all over the world, those quoted ranging from Alexandria to the Bahamas.

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Trouble Discounted

An analysis of 40-odd annual statements of chairmen of engineering and metal manufacturing companies published recently shows that few are considering the Suez crisis as very much more than a temporary nuisance which may or may not have an impact on the current years' profits but which should certainly not have a very serious effect on their companies' healthy order books. There is far more talk of expansion, re-equipment, rising demand and of obstacles to growth, such as the shortage of certain types of steel and certain grades of workers. Basically, running through most of the reports, there is confidence in the long-term future of British engineering and—with the exception of certain motor manufacturers and their suppliers—confidence that activity in 1957 will not be less than in 1956, despite our troubles, and might well be more. It is a cheerful picture, marred only by the almost universal complaint that costs are rising too fast—with the inevitable warning about the dire consequences of any substantial wage awards to the engineering workers—and that profit margins are not what they were. The most encouraging feature of the reports is the constant emphasis placed on investment in the most up-to-date plant and manufacturing processes. No one reading through these reports would conclude that there is very much wrong with the industry; on the contrary, that its competitive strength is steadily increasing and its commercial aggressiveness becoming more marked.

To illustrate the foregoing remarks we quote some of the chairmen's comments on their companies' prospects. Mr. J. J. Parkes of Alvis Limited said with reference to the Suez situation that trading prospects for the next year "would not differ appreciably from those in mind when the statement was written." Orders for aircraft engines and helicopters are very satisfactory. Mr. David J. Grimes of Dennis Brothers, Limited, considered that his company's prospects "based on hard selling, remain satisfactory within the foreseeable future." Mr. W. Edgar Hale, of Hale and Hale (Tipton), Limited, reports a continued increase during the current year, despite the slowing down of demand from the motor industry which "has not, as yet, affected production to any large degree." Mr. J. D. McKechnie of McKechnie Brothers, Limited, complains of shortages of materials and rising costs but concludes by expressing his confidence that "by improved efficiency, coupled with the high quality of our products (non-ferrous metals and heavy chemicals) we will be able to meet more difficult times and increased competition."

Thus metal and engineering companies are emerging resilient from a year that has, for a good many, been a difficult one. Most of them would agree with Mr. A. E. Lines of Lines Brothers, Limited, who, although he finds the present international complications affect toys as well as any other engineering product, says, "if the problems which arise from these unsettled conditions can be overcome, we have every confidence in the continued prosperity of the Group."

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Standard Motors Policy

"No name, no pack drill" seems to have been in Lord Tedder's mind when he addressed the shareholders of the Standard Motor Company last week. The mysterious buyer who has acquired more than 3 million of the company's shares in the past few months was not named as was widely expected he would be. He is known to Lord Tedder who considers him "friendly" and unlikely "to interfere with our plans to continue aggressively in the car and tractor business." In the circumstances it is strange that the name should be withheld, particularly in view of the considerable difficulties the company are now facing in competition with the giants.

Standard's greatest asset is generally considered to be the Ferguson tractor made for Massey-Harris-Ferguson under a long-term contract. That company had every reason to view with alarm the distressing developments of the summer when the Standard management ran into serious labour troubles over redundancy. The new Ferguson tractor announced last month has been very well received by distributors and dealers throughout the world, and Lord Tedder told his shareholders that Massey-Harris- Ferguson were confident that a high volume of sales would be achieved "provided that costs are maintained." The quality of the management at Standards is a vital concern of Massey-Harris-Ferguson. Another possible interested party is Mr. Harry Ferguson himself who sold his interest in the factor to Massey-Harris for more than £5 million in order to devote his energies to the development of novel systems of chassis, transmission, suspension and braking through Harry Ferguson Research. Mr. Ferguson has found it difficult to interest British manufacturers in taking up his projects and rumour has it that he and the Standard Company have undertaken a joint development project. In all likelihood, therefore, the mystery buyer is either Massey-Harris-Ferguson or Mr. Ferguson himself.

The company's product policy may be sound, but its implementation has certainly left much to be desired. The reduction of the dividend from

12 to 8 per cent. does not reflect in full the disastrous loss of ground during the year. The car side needs strengthening, particularly its marketing organisation, and it may well be that Mr. Ferguson's genius will prove the rest of the industry wrong and put Standard back among the leaders.

* * *

A Crisis Deepens

Lord Tedder, chairman of the Standard Motor Company, whose policy is discussed in another note, uttered a serious warning that a major crisis in the car industry is unavoidable and called for emergency action on the part of the Government to relieve the industry from some of its more crushing burdens. Petrol rationing and taxation had virtually closed down the European and British markets. "This cannot but result in an immediate and drastic reduction in output—with the inevitable consequent increase in production costs." In addition, the resumption of the inflationary spiral due to the fuel crisis, particularly the higher transport charges and the increased price of steel, are threatening to cripple the industry's competitive ability abroad. Lord Tedder foresees "every prospect of the whole industry being involved at a very early date in a dangerous crisis," short of immediate and drastic Government action.

This is by far the most gloomy but also the most recent authoritative statement made by a member of the industry. Reporting another year of record sales, Mr. Ralph Gordon-Smith, chairman and managing director of S. Smith and Sons (England), Limited, foresees a continued high level of activity but also takes a serious view of the economic consequences of the Middle East crisis on motor car output. Although, therefore, the company's aircraft, industrial and marine activities are continuing to expand and order books are very large, the figures from August 5 to date indicate that "the maintenance of last year's results will be difficult." Nonetheless, Mr. Gordon-Smith is confident that the motor industry, given normal conditions, would soon re-establish itself at a reasonably satisfactory level for, in his view, the motor trade is "well founded" and "energetic and resilient." There is also a note of confidence in Sir Leonard Lord's review of the British Motor Corporation's prospects.

The companies in the industry which are being really hard hit are those making specialist cars, in relatively small volume. Although they are more flexible and able to withstand sudden temporary drops in output as at present without greatly increased costs, the intense competition developing is tending to drive their cars out of the market. The heavy loss recorded by the B.S.A. company's motor car division illustrates the difficulties which specialist car manufacturers are now facing. Inevitably, the few remaining independent producers will either be absorbed by other companies or the cost of making such cars will increasingly become a charge on large companies' other products. Yet it is as well to remember a statement made in the Spaak report discussed in another note: "There is no motor car manufacturing firm in Europe which is big enough to take full advantage of the most powerful American machinery."

* * *

Retirement of Dr. Albert Parker, C.B.E.

The Department of Scientific and Industrial Research have announced that Dr. Albert Parker, C.B.E., Director of Fuel Research since 1943, is retiring on December 31 after 28 years service with the Department. There can be few men with such a wide and detailed knowledge of all forms of fuel as Dr. Parker. It is therefore not surprising that he will probably continue to be active in this field by doing some consulting work.

Dr. Parker was educated at Manchester Grammar School and at Manchester University, where he graduated with first-class honours in chemistry in 1912. During the subsequent two years he was a graduate scholar and Beyer Research Fellow of Manchester and carried out researches on the combustion of gases and on the specific heats of gases at high temperatures. From 1914 intil 1919 he was lecturer in physical chemistry and thermodynamics at the University of Birmingham and was also chemist inspector on the manufacture of high explosives for the Midland Area. He was awarded the degree of D.Sc. (Birm.) in 1916. In 1919, as research chemist to the University of Leeds and the Institution of Gas Engineers, Dr. Parker conducted investigations, using pilot apparatus and full-scale plant, on processes of coal and water-gas manufacture, the recovery of by-products and the treatment of gasworks effluents.

He joined the Department of Scientific and Industrial Research in 1928 as assistant director of Water Pollution Research and served as Director of this branch of the Department's work from 1939 until 1943.

Dr. A. C. Monkhouse, at present deputy Director of Fuel Research, has been appointed acting Director with effect from January 1, 1957.

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Obituary

MR. H. J. F. GOURLEY

President of the Institution of Civil Engineers

Mr. H. J. F. Gourley, the President of the Institution of Civil Engineers and the senior partner in the firm of Binnie, Deacon and Gourley, consulting engineers specialising in water supply, irrigation and power, sewerage and sewage disposal, died in hospital on Tuesday, December 18, at the age of 70. He thus died only some six weeks after being formally inducted into the President's chair.

In his presidential address, he chose to deliver a strongly worded criticism of the profession, drawing particular attention to the relatively small proportion of associate members of the Institution that were going on for full membership. It was the shortsighted conditions of employment within the civil service, the nationalised industries and the like, requiring only corporate membership which was satisfied by associate membership, that caused some to take the view that there was no need to seek transfer. The young engineering graduate of to-day was much too inclined to take as his first appointment that which carried the highest salary—more often than not offered by a nationalised industry or a similar large concern—and such an approach was, he considered, one of the factors which accounted for the declining prestige of the civil engineer. It should be a far more important aim of the young engineer to gain good experience in both design and on works construction and subsequently to broaden his experience in both fields. With such a foundation his future was then assured.

When the Institution was formed in 1818 its members had been mainly self-employed. They had a tradition of personal service and professional pride which was irrespective of fee or reward. Consequently their services to the community had been recognised, and the profession had achieved a status that was maintained till at least the turn of the century. To-day the number of self-employed or consulting engineers was relatively small, though the number engaged by them or working under their direction was more substantial. The greater proportion, however, were engaged with the large organisations already mentioned, and there was not in those organisations, Mr. Gourley felt, the opportunities for the exercise of initiative and independence as there were in other spheres, and without those opportunities it was difficult to qualify for transfer to full membership.

Harold John Frederick Gourley was born in Liverpool in 1886, and educated at the Institute there before passing on to the City's own University where, in 1909, he graduated with first-class honours. He stayed on at the University, engaged on hydraulic research, for the following year. During that year he presented a paper on concrete and reinforced-concrete piles to the North-Western local association of the Institution, which he had just joined as a student, and gained the first of the two Miller prizes he was to be awarded.

In 1910 he joined, as a pupil, the firm then known as Sir Alexander Binnie, Deacon and Sons, with which he remained throughout his life, being taken into partnership in 1935 and, ultimately in 1949, becoming the senior partner in the firm, which had been renamed Binnie, Deacon and Gourley. His firm was responsible for many water supply and allied projects in the United Kingdom and throughout the Commonwealth so that, during his career, Mr. Gourley travelled widely. He was charged with the construction of, among others, the Hong Kong Government's Gorge Dam which, of novel design, is one of the highest dams in the Commonwealth and impounds 3,000 million gallons of water. As an acknowledged authority on water engineering he sat on many committees and gave evidence before numerous others. In 1949 he was a member of the panel of four who inspected and reported on the Kariba and Kafue hydro-electric projects.

Mr. Gourley was a member of the Institution Floods Committee, and also helped to prepare the 1938 Code of Practice for the design and construction of reinforced-concrete structures for the storage of liquids. He was also nominated by the Institution as a member of the codes of practice committee set up by the Ministry of Works in 1942. He won two Miller prizes as a student and later was awarded two Telford Premiums for papers on water supply; he was elected an associate member in 1913 and was transferred to the class of full member in 1922. He was a member of council from 1941 to 1946, and again from 1949 to date, becoming a vice-President in 1952. In addition to his work for the Institution of Civil Engineers, he had been President of the Institution of Water Engineers in 1935 and, in 1942, he served as chairman of the Association of Consulting Engineers. A short while ago he was elected a life honorary member of the American Society of Civil Engineers. In 1951, Mr. Gourley suffered an unfortunate accident when a Liverpool express was derailed, losing his right arm and left leg, as well as incurring other injuries. His recovery was remarkable and, though well into his sixties, he taught himself to write with his left hand and re-assumed the responsibilities that were to take him to that high office in which he was recently installed.

OTHER SOURCES OF FUEL AND POWER

The temporary reduction in oil supplies to this country and western Europe gives special significance to other sources of fuel and power, and to more efficient ways of using all sources. Here is a brief review of the less common alternatives, based on the papers given at the World Power Conference earlier this year and supplemented by later information. The use of fuel in gas-turbines, heat pumps and district heating was reviewed in our issue of July 13, page 34, and this article completes that review. Most of the sources of fuel and power mentioned here are not, of course, of much direct significance in Britain, or in industrialised countries generally, but they are certainly of great importance to makers of engines and plant designed to utilise these fuels, such as gas-turbines, steam engines, boilers, etc.

WOOD

Though wood is usually regarded as a raw material of industry rather than as a fuel, there are a few countries where it is important in power production, especially if other fuels in solid or liquid form have to be imported. In Sweden, for example, wood met 17 per cent. of the fuel demand between 1949 and 1953. About a third or a quarter of the timber felled annually is used as fuel. In Finland a considerable quantity of wood is used as fuel, and even in Canada a large part of the space heating is by wood.

Perhaps the most interesting exploitation of wood is to be found in the U.S.S.R., where systems of combined steam generation and chemical utilisation have been developed. There were previously a number of small and medium steam generating plants using waste from the timber and wood-working industries, but a greater overall economy is envisaged in the design of plants in which the steam generation is combined with the production of chemicals as by-products. Thus it is possible to obtain certain acids, tars, alcohols, combustible gases, etc. The residual fuel is then used for generating power. The first combined industrial boiler unit with chemical processing in the U.S.S.R. is reported to operate on wood refuse—a material which is available in considerable quantities in certain Russian industries. In Finland, too, it is reported that waste liquors of the wood pulp industry are used for producing power, though it is considered that only half of the energy available in this form is so used. In Chile it is hoped that the waste products of a paper factory and a cellulose factory will be used for the production of electric power.

In a highly industrialised country any use of vegetation for power is not likely to be on a large scale. Even so, the United States derives about 5 per cent. of its heat and power from the combustion of wood (though only about 0·3 per cent. of electric power).

In general, wood is such an important raw material, and is being used at such a rate in relation to the "output" of world forests, that its use as a fuel is likely to decline except in a few localities where special economic and other conditions exist. Increasing attention is being paid in some countries to the urgent need to extend the areas devoted to forestry. Two contrasting examples are the United States, where the demands on lumber production and forest reserves have risen considerably, and Pakistan, where it is officially declared that the proportion of land under forest should be increased from the present figure of 2·5 per cent. to about 25 per cent.

In India, wood and wood charcoal are still important fuels in industry as well as in homes and cottage industries, and even in the future a large part of the rural population that is inaccessible for rail transport will depend on wood and farm wastes for power generation for some years to come. Wood is, after all, one of the few forms of energy that is inexhaustible—provided the harvesting does not exceed the planting. In Japan the one exceeds the other to such an extent that, in spite of about 68 per cent. of the land being covered with forest, a very serious situation has developed and urgent steps have been taken to improve the economy of use, particularly by better design of domestic wood-fired ovens.

PEAT

Countries in which peat is important include Ireland, Scotland, U.S.S.R., and Sweden, though there are vast resources of peat, scattered in many parts of the world, which will become of increasing importance as other solid fuel reserves contract. That, at least, is the view of the Irish engineers who have done so much to exploit the possibilities of this fuel. The future of peat in Irish industry has been summarised in the following terms (applicable, no doubt to other countries):

"It is practically certain that future peat-burning generating stations will be based on the use of milled peat, due to the much lower cost of the fuel and the greater certainty of harvesting it. These stations can be built on, or close to, the bogs, thus eliminating heavy transport costs. Industrial establishments elsewhere will, however, have to depend on sod-peat for their requirements. In the case of such installations, improvement in peat combustion must proceed from combined efforts in the spheres of production and utilisation. Production development must be aimed at producing a fuel, not necessarily better in quality, but superior from the point of view of uniformity. To a great extent the fluctuations in moisture content experienced with peat fuel are due to the reversibility of the drying process. Present experiments in peat maceration appear to hold out some hope of producing an appreciably denser fuel which will have less tendency to re-absorb moisture in wet weather once it has been dried. In the sphere of utilisation, it will be necessary to design furnaces according to the principles which have already been established for peat combustion. In the past, industrialists have tended to install plant primarily designed for coal, and the conversion of such plant to peat firing has been largely a matter of makeshift arrangements. This attitude is already disappearing consequent on assured supplies of cheap peat fuel, and no doubt an increasing number of industrialists will install plant primarily designed for the national fuel."

The work in Scotland on the use of gas-turbines for running on peat is well-known. A report from Western Germany refers to steam power plants in which peat, brown coal, and black coal can be injected simultaneously in pulverised form.

TIDAL POWER

The tidal power of the world, like wind power, is enormous, but the engineering and economic difficulties of harnessing it are formidable. France is farthest ahead in this field. The advanced schemes for tidal power plants in that country are designed so that the turbo-generators can be run not only in the normal manner to develop power but also as pumping units in pumped storage schemes, thereby making additional power available at times when it is most required.

Among the countries which might benefit from exceptional differences in high and low tides are Pakistan, Chile, and Australia (especially along the northern coast).

The idea of constructing a tidal power plant in the Severn estuary in England has been discussed. Such a plant, it is estimated, would save the equivalent of a million tons of coal per annum. But the total cost, including the dam, would amount to £100 million—and half this money, if invested in improved domestic heating appliances in Great Britain, could save us 20 million tons of coal per annum.

WIND POWER

The wind power of the world has been estimated at 3×10^{17} kW; the same authority believes that 2×10^{10} kW could be utilised. But there are two factors which militate against the practical use of wind power: its variableness and the capital cost of suitable plant. Considerable work has been carried out in this country and has been reported in ENGINEERING from time to time. Reports from the few countries which express interest are not very encouraging, though if we take India as an example of a "new" industrial country which is giving serious consideration to the subject, there may be some grounds for believing that wind power may come into its own as the economic pattern of different sources of power changes—as change it will.

In an official Indian statement it is argued that wind power "should be of practical significance in a country like India." It is believed that extensive use of small windmills by farmers and village communities would fit in well with the general pattern of the Second Five-Year Plan to increase the production of consumer goods as much as possible through household or "hand" industries. Surveys carried out in India have shown that the prospects of wind power utilisation are favourable in various regions of Rajasthan and the west coast. A project for setting up a number of small units and medium-size units for irrigation and rural electrification purposes has been formulated. Data on wind velocities are being collected.

SOLAR ENERGY

The amount of energy received by the earth from solar radiation is about 35,000 times the present annual energy consumption of mankind. If it were possible to transform a ten-thousandth of this radiation directly into power, the world's energy production would be increased by 250 per cent. Or, to take yet another example, the solar energy received by the United States is between 20 and 30 times the electrical energy produced in that country. At the present time the economics of using solar energy are not encouraging, though a certain amount of investigation is being continued, particularly in the United States and several countries where the solar energy characteristics are favourable. People working in this field believe that there are many aspects of physical chemistry, physics, and engineering where fundamental research may lead to significant advances in the future. The National Physical Laboratory of India is doing work on solar energy, and it is believed that for refrigeration and air conditioning it has possibilities in tropical countries like India. Some solar water heaters have been installed in private homes in Australia, and solar boilers for domestic hot-water supply are made and sold on a limited scale in Israel.

GEOTHERMAL HEAT

Among the various places in the world where geothermal heat is available, Italy has, so far, taken the greatest advantage of this phenomenon. Steam which escapes from the earth under pressure is being used to an increasing extent for producing power, with borax and other chemicals as useful by-products. The installed capacity of generating stations connected to a total of about 140 steam wells is now more than 400 MW.

Iceland, New Zealand, Mexico and Japan also have geothermal heat resources. In Iceland, where there is a lack of indigenous fuels, geothermal heat is used on a considerable scale. The heat from hot springs supplies a greater proportion of the total energy requirements than in any other country. Some 250 hot springs run

at temperatures up to 100 deg. C., and there are 12 wells of considerably higher temperature supplying steam under pressure. It is believed that the reserve of geothermal heat in nine of the principal wells amounts to about a million kWh per person of the population, which is about the same amount as the average per person for the world's total reserves of fossil fuels. The steam wells in Iceland have not, so far, been used for electricity supply to any appreciable extent, as hydro-electric power is meeting the main demand, but the springs are used extensively for heating, more than half of the inhabitants of Reykjavik living in houses centrally heated by this means.

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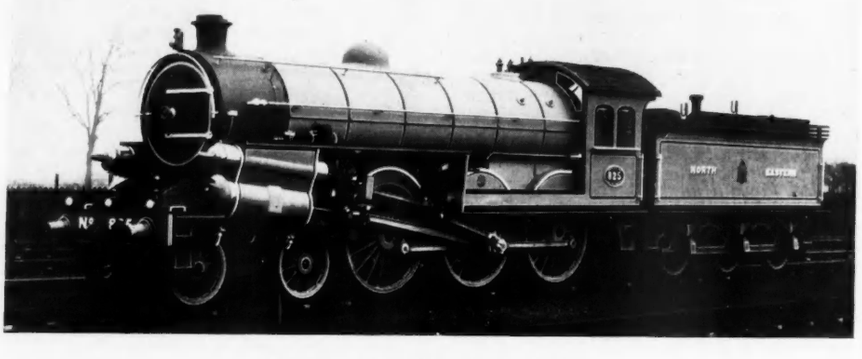
NATURAL GAS FOR ENGINES

The performance of methane and propane in internal-combustion engines is of interest for two reasons. First they are available as natural or waste products in abundant quantities, and the supply of propane is also being rapidly increased by the expansion of catalytic cracking in petroleum production. Second, both fuels are available in relatively high state of purity. In a paper entitled " Comparative Studies of Methane and Propane as Engine Fuels ", which was presented to the Institution of Mechanical Engineers by Mr. N. P. W. Moore and Mr. B. M. Roy, both of Imperial College, London, tests carried out with these two fuels are discussed.

A Ricardo E.6 variable-compression spark-ignition engine was used. The methane was obtained from the Mogden Works of the West Middlesex Main Drainage Board, and was of 90 per cent. purity, while the propane used was more than 98 per cent. pure. Tests carried out, mainly at 2,500 r.p.m., showed that steady running was possible with both gases at this speed. The range of power control by quality governing is greater than with petrol and is rather wider with propane than with methane, being in the region of 80 lb. per sq. in. mean effective pressure. Both fuels were suitable for use in engines of high compression ratio, that is to say, above 10-1, with consequently high engine efficiency. An indicated mean effective pressure of about 167 lb. per sq. in. was obtained with propane, but both fuels were sensitive to heating of the incoming air.



4-6-0 locomotive with uniflow cylinders.

THE EXPERIMENTAL SPIRIT

3—CYLINDER VARIATIONS AND COMPOUNDING

By C. R. H. Simpson, A.I.LOCO.E.

The third of a series of articles on unsuccessful experiments to make the steam locomotive competitive with electric and Diesel traction. The first two articles appeared on page 610, *November* 16, *and page* 674, *November* 30.

CYLINDERS

Sir John Aspinall's attempts to improve cylinder efficiency by steam-jacketing the cylinders[50] were commenced in 1894, and are thus strictly outside the period covered by these notes; but they were of interest for, *inter alia*, they preceeded an attempt by de Kossuth of the Italian State Railways to attain a similar end by circulating smokebox gases around the cylinder walls and covers. The result of several months working on an engine so equipped was stated to be an economy in fuel of 11 per cent. However, as has been so often the case, the savings which on paper appeared worth-while were not in themselves sufficient to ensure the success of the device concerned. In this instance the removal of the cylinder cover became considerably complicated while a bigger disadvantage was that an appreciable quantity of cinders and dust was drawn into the casings and had to be removed every few days. Although this device was fitted on many Italian locomotives and its use extended to France and Hungary, it was not perpetuated. Ultimately the advent of the superheater effectively closed the book as far as ideas to cut down cylinder condensation were concerned.

Generally, efforts to improve cylinders on locomotives took two basic forms: (1) alterations in the arrangement of ports and passages, and (2) alterations in the disposition of the cylinders themselves. Attempts to improve cylinder performance were usually made by the use of compounding or ultra-high pressures, the latter technique requiring special types of boilers which are dealt with under that heading.

The Stumpf, or uniflow, cylinder, and with it the special piston, was probably the boldest departure from conventional practice. The first engine so equipped belonged to the Prussian State Railways and was exhibited at the Paris Exhibition of 1910. It was introduced into Britain by the North Eastern Railway, 4-6-0 No. 825 being so fitted in 1913 and 4-4-2 No. 2212 in 1916. In the Stumpf arrangement both cylinder and piston were considerably lengthened, the former by some 50 per cent. Exhaust ports were annularly disposed at the centre of the cylinder and, as the piston was approximately half the length of the cylinder, were uncovered towards the end of the piston stroke. Since the steam flow was uni-directional, i.e., from the ends to the centre, this type was also known as a uniflow cylinder. In fact when working at long cut-offs, some of the steam also exhausted through the steam ports. As this to some extent undermined the advantage claimed for the system, i.e., the prevention of condensation arising from abrupt changes of temperature, it was deemed necessary to provide a degree of compression; in fact the compression was very great as it lasted almost the whole of the return stroke.

An obvious disadvantage was the greatly increased weight; and in inside-cylindered engines—much in vogue at this period—the increased length was also a difficulty. Large clearances were necessary and in one example these were 17·5 per cent. While No. 2212 was reported to be lighter on coal than all other engines of its class, any promise this layout may have possessed was nullified by the introduction of superheating.

It is interesting to note that a basically similar principle was used by C. W. Paget in his highly ingenious but unsuccessful locomotive built in 1908, and, going further back, central exhaust ports were used in the South Eastern Railway's locomotive " Man of Kent " built by Rennie in 1843.[51] The engine of the Winterthur high-pressure locomotive was of the uniflow type.[52]

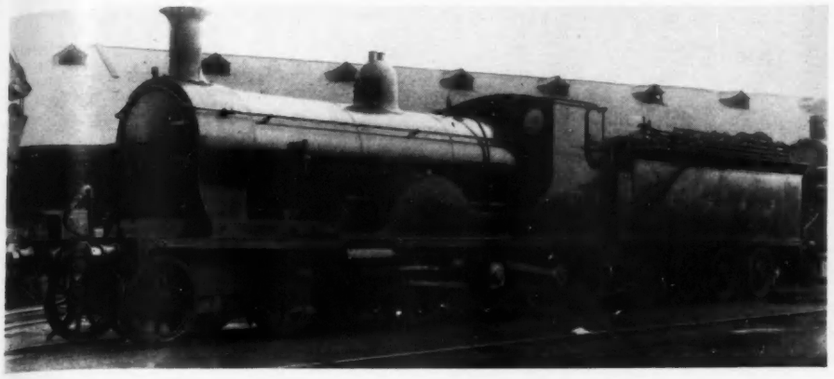
Dendy Marshall, in his four-cylinder system, set out to simplify the front-end by arranging for an inside cylinder and an adjacent outside cylinder to receive steam from valves mounted in tandem on a common spindle; one valve had inside admission and the other had outside admission. The arrangement necessitated the outside cylinders being set back somewhat, relative to the inside ones, in order to bring the front port of the outside cylinder opposite the back port of the other. L.N.W.R. " Experiment " class locomotive No. 1361 " Prospero " was so fitted by Bowen Cooke in 1915. The results as reported on test were—as is so frequently the case—fairly good. But again, as is so often the experience, they were not deemed sufficiently good to warrant any further engines being altered. " Prospero " spent the remainder of its days—until 1933—in the four-cylinder state. Dynamometer car records, taken in the altered condition, showed a starting pull by " Prospero " as high as 16 tons, which for an engine with four 14 in. by 26 in. cylinders, 6 ft. 3 in. wheels and 175 lb. per sq. in. boiler pressure, is extremely high.

It should be remembered that about this time there was a trend towards simplicity, and railways which over a period had used four-cylinder engines, e.g., the Paris-Orleans Railway, were reverting to two-cylinder locomotives for new construction.

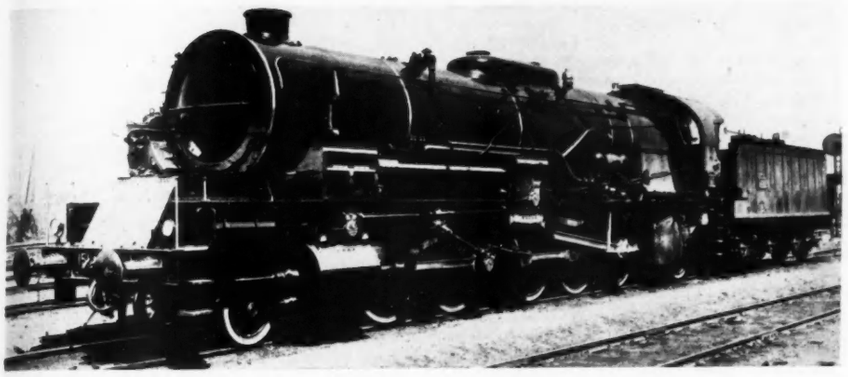
Dendy Marshall's idea was not unique, the Italian State Railways on their 2-6-2 four-cylinder locomotives used only one valve for two cylinders. They were in line and, while the inside cylinder ports and passages were arranged as usual, the passages of the outside cylinders were crossed-over. The crossed-port layout was also employed in America. Large clearance spaces were a bad feature of the designs mentioned.

Great Central Railway four-cylinder locomotives in which vertical rocking arms were used had them below the horizontal shaft on which they were mounted, driving valve spindles of an inside and outside cylinder respectively. This arrangement, which meant that the two valve spindles each moved in the same direction when the pistons were moving in opposite directions, necessitated one set of cylinders the inside ones having inside admission and the other set having outside admission.

The 0-10-0 locomotive built by the Midland Railway, for banking on the Lickey incline, had an unusual valve arrangement in that the front piston-valve head served the front port of the outside cylinder and the pack port of the inside cylinder, and vice versa, the ports of the inside cylinder being crossed. The purposes of this design were to avoid complication and to remove the difficulty of locating valves for the interior cylinders under the smokebox floor. The disadvantage lay in the disparity of the clearance between the direct and cross-ported cylinders, but on such specialised duty, where the engine is



British 4-2-2 locomotive with divided drive.



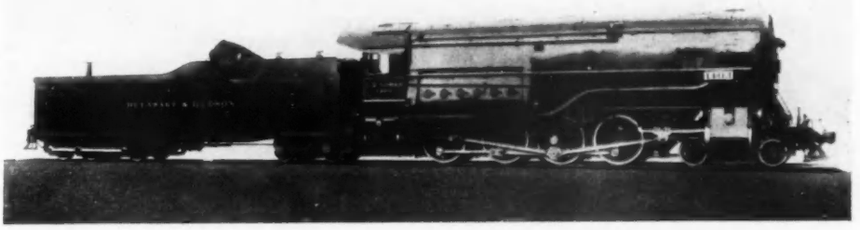
French locomotive with divided drive.

only working for short periods, the objection is more theoretical than practical. The cross-porting arrangement was also employed on the four-cylinder G. and S.W.R. locomotive when rebuilt by Mr. R. H. Whitelegg in 1922. This enabled one valve to feed two cylinders.

Some cylinder layouts have had little or no application in Great Britain, in some instances due to the arrangement being associated with forms of compounding not used in this country. Examples are: tandem arrangements, which have not been used here since the Great Western Railways' experiments with this form of compounding terminated in 1892[53]; and superimposed cylinders as used in the Vauclain compound, in which the high-pressure cylinder was above or below its corresponding low-pressure cylinder—both piston rods being connected to one cross-head. The loading gauge was not altogether in favour of the last-mentioned system, and in any case those British chief mechanical engineers who favoured compounding were wedded to other systems.

Opposed pistons, though now fairly common in internal-combustion practice, have had some application in steam locomotives. They have been used infrequently in Continental practice; between 1906 and 1908 Maffei produced a four-wheeled tank locomotive for the Bavarian State Railways which had inside-coupled axles, each driven from outside cylinders placed midway between them.[54] The idea has recently been revived in Russia[55] where the 2-10-6 "OR" class has the cylinders placed high up over the middle coupled axle. The drive is taken through "balancers" in much the same way as that adopted by Brown for tramway locomotives. The chief attraction of the increased complication is in the balancing and disturbing forces to some extent cancelling out.

A most unusual cylinder arrangement resulted in the Delaware and Hudson Railroad four-cylinder triple-expansion locomotive shown at the Chicago Exhibition of 1933 (shown on this page). It had a high-pressure 20 in. by 32 in. cylinder under the driver's side of the cab, an intermediate-pressure cylinder 27½ in. by 32 in. under the fireman's side, and two low-pressure cylinders 33 in. by 32 in. in the usual position below the smokebox. All cylinders were connected to the second coupled axle.



A four-cylinder triple-expansion design.

Multi-cylinder arrangements on simple locomotives have been legion and no attempt is made here to cover all of them. One of the early examples of multi-cylinder drive was the Paget locomotive[56] on the Midland Railway. Built at Derby, 1907-8, this 2-6-2 engine had eight single-acting cylinders 18 in. diameter by 12 in. stroke; four of these drove the centre axle (two being located vis-à-vis) and two were connected to each of the other axles.

In the four-cylinder 4-4-4-4 design of the Baltimore and Ohio Railway, No. 5600 built in 1936, each group of driving wheels was connected to two 18 in. by 26½ in. cylinders located at the outer ends of each coupled wheel group.

A French 2-10-0 four-cylinder compound was rebuilt as a 2-12-0, and, as two sufficiently large low-pressure cylinders could not be accommodated, four low-pressure cylinders were employed, taking steam from two high-pressure cylinders. This scheme, suggested by M. Chapelon, had the advantage that the drive was distributed over three wheel pairs.

The "Leader" class designed by Mr. O. V. S. Bulleid had three inside cylinders per bogie, the general application being distinctly novel; while there was no other similarity, a three-cylinders per engine unit had also been employed in another articulated locomotive—the 2-8-0 + 0-8-2 Beyer-Garratt locomotive supplied by Beyer, Peacock and Company, Limited, to the L.N.E.R. in 1925. This engine was the first six-cylinder Garratt ever to be built; it had a tractive effort of 72,930 lb. (at 85 per cent. B.P.)—a figure greater than that of any other steam locomotive ever placed on British rails.

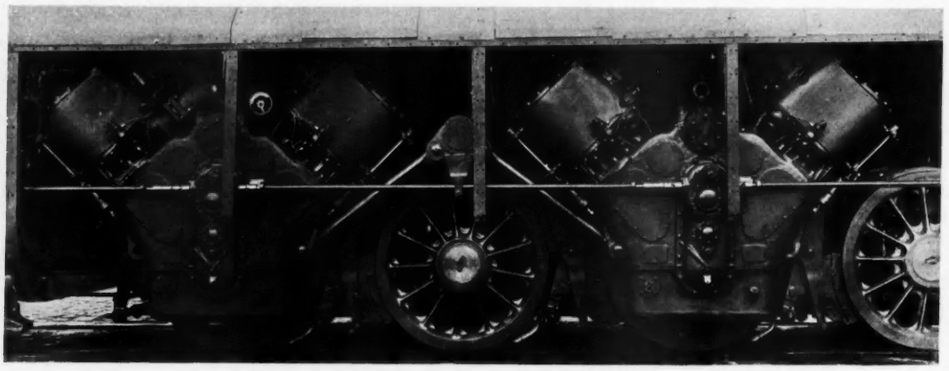
In the late 1930's a spate of designs for multi-cylinder locomotives was produced, incorporating individual axle drive. Due to the war, few of these ever progressed further than the drawing board. At the time mentioned—which marked the zenith of the steam locomotive—there was a tendency for high speeds to become even higher, and a stage had been reached where some reduction of unbalanced, and unsprung, masses was desirable. This was particularly so in America, where the steam locomotive had reached such vast proportions that it was regarded in some quarters as rather out-of-hand. As examples may be quoted cylinders 30 in. by 34 in. developing thrusts of some 220,000 lb. and necessitating crankpins of 11 in. diameter, and axles of 15 in. diameter: a lot of unsprung weight and much of it unbalanced. Yet even these unusually large dimensions did not ensure freedom from fracture of axles and crankpins.

An example of multi-cylinder designs was the 16 cylinder 4-8-4 design of the Baltimore and Ohio R.R. which would have employed 9½ in. by 7 in. cylinders. American interest in multi-cylinder locomotives was also evidenced by the "collection" by the American authorities in 1945, after the occupation of Germany, of the 1-Do-1 locomotive completed by Henschel and Sohn in 1941.[57] Each driving axle was powered at one end by a V-twin steam engine, the drive being of a link type as used on some electric locomotives. The design was intended for rail speeds up to 109 m.p.h. which with the 49½ in. wheels would have involved an engine speed of 800 r.p.m. The cylinders were 11·85 in. "square," and, while in such a design an ultra-modern valve gear might be looked for, the motion was imparted by simple eccentrics gear-driven from the crank axle, not even a link being interposed. Unlike the majority of multi-cylinder locomotives with individual axle drive, this locomotive had an orthodox boiler. With but two exceptions individual axle drive has not been employed with a Stephenson boiler.

As a traffic machine the advantages of the Stephenson engine are simplicity and reliability, and these qualifications have proved sufficiently strong arguments to overcome the application on any scale of individual axle drive.

The Swiss Locomotive Works regarded the use of two vertical engines per axle as practical.[58] A considerable number of designs was prepared by the French prior to the war for multi-cylinder locomotives[60] but owing to the war only one of them was built—the 4-6-4 for the C. de F. du Nord, constructed by the Swiss Locomotive and Machine Company.[60]

What is usually regarded as the first use of individual axle drive was made by Sentinels in



Detail of individual axle drive on a German locomotive.

three locomotives[61] constructed in 1934 for the Columbian National Railways.

Attempts to improve torque have led to departures from 90 deg. crank settings on four-cylinder engines. The method adopted on the S.R. " Lord Nelson " class in 1926, was to turn the cranks of the inside cylinders through 45 deg.; this resulted in a more uniform turning moment but resulted in balancing being more difficult. However, these locomotives had connecting rods of alloy steel, which helped the balancing to some extent as the weight was reduced. Similar crank spacing was previously used in the four-cylinder 0-6-0T built to the designs of J. A. Hookham by the North Staffordshire Railway in 1922. Tests carried out on the Southern Railway showed that the coal saving achieved with the altered crank setting, which produced eight exhaust beats per revolution on a four-cylinder engine instead of the customary four beats, was 9·5 per cent. in ton-miles and 14·9 per cent. in train-miles.[62]

The three-cylinder 4-4-4 compound locomotive built by Henschel and Sohnin 1904 for the Prussian Railways had an inside high-pressure cylinder driving the leading coupled axle and two outside cylinders driving the trailing coupled wheels. While this engine was in many ways a remarkable one, the most extraordinary feature was the setting of the crankpins of the trailing axle, these being located in the same plane, both low-pressure pistons moving together at an angular spacing, relative to the inside crank, of 90 deg. This setting was achieved by the fitting of the outside big-ends on return cranks.

The purpose of this unusual arrangement was, no doubt, to suppress disturbing forces and to abolish " nosing." Although at first this may appear to have been a bad arrangement mechanically, it apparently gave little trouble for when the engine was altered in 1912 it was retained.

COMPOUNDING

Probably more thought has been devoted to compounding than to any other aspect of the locomotive except blast arrangements. For whereas a good few locomotive superintendents, and later chief mechanical engineers, had ideas on compounding, nearly all of them thought out ways of improving what the Americans included in that expressive phrase " front end conditions."

At the turn of the century—which is approximately the starting point of this resumé—compounding was in full flood. F. W. Webb's efforts, adequately chronicled elsewhere and the subject of an absorbing correspondence—in this journal—between the inventor and his critic " Argus," had proved unsuccessful to the world at large, however successful they may have appeared to Webb.

So many systems were produced that merely to catalogue the names would require excessive space, and it must suffice to give the principal features of classification, with a few examples. The two-cylinder non-automatic system was evolved—among others—by Worsdell and von Borries; in Britain it was employed on the North Eastern and Great Eastern Railways in the late 1880's, and later (1890-1908) two-cylinder compounds were built by Beyer, Peacock and Company, Limited, for Ireland (B. and N.C.R.). The Worsdell compound was summed up by E. L. Ahrons as doing good work in the day when locomotives of medium power were sufficient.[63] The two-cylinder automatic system, also used by Worsdell, found some favour on the Continent and in America, e.g., the Roger's system.

The three-cylinder system was extensively employed, with very different results, by Webb and Smith; the Smith system had the distinction of being the most widely used in Britain. Originating on the North Eastern Railway, it was taken up by Johnson of the Midland Railway and continued in favour on that line until grouping in 1923. Later still it was built in large numbers by the L.M.S.R. Whereas in the Midland design all cylinders drove one axle, in the Smith design, as used by J. G. Robinson on the G.C.R., the drive was divided.

Four-cylinder systems were basically two or four crank. Two-crank systems included tandem compounds. After 1900 these were built for a few years for North American railways only, save for two supplied to the Cape Government Railway, the largest user being the Santa Fe, who possessed 159 such engines.[64] Another two-crank system was the Vauclain, mentioned in the section of this article referring to cylinder arrangements.

The four-crank four-cylinder system was used in Britain on the L.N.W.R., G.W.R., G.N.R., L. and Y.R. and N.E.R. But whereas in the Webb and Smith four-cylinder arrangements the drive was on to one axle, in the de Glehn arrangement, as used on the G.W.R., the drive was divided.

The last work carried out in Britain with compounding was the construction of experimental locomotives on the L.M.S.R. and L.N.E.R. In 1926 George Hughes converted one of his four-cylinder 4-6-0s, No. 10456, to compound expansion, with a view to obtaining information in connection with proposed four-cylinder 4-6-2 and 2-8-2 compounds. The designs were not proceeded with and No. 10456 was broken up in 1936. On test with 350 ton trains between Crewe and Carlisle it burnt 3·67 lb. of coal per d.b.h.p. per hour, compared with the 4·0 lb. of the simple engine—a saving of 9 per cent.[65]

Sir Nigel Gresley's locomotive No. 10,000, of 1929,[66] was a four-cylinder compound and had the abnormal working pressure of 450 lb. Unfortunately—as is only to be expected in a design which departed so radically from the orthodox—there were many difficulties in service.

Between 1925 and 1930 experiments were conducted in America with high-pressure compounds,[67] and in 1933 the Delaware and Hudson Railroad carried out tests with the 4-8-0 four-cylinder triple-expansion locomotive, No. 1403.[68] This is believed to be the second application of the triple-expansion principle to locomotives, the first having been by F. W. Webb in 1895.

The subject of compounding the world over was adequately dealt with in many papers presented to the Institution of Mechanical Engineers; the authors included F. W. Webb, Edward Sauvage, G. Hughes, and A. Mallet.

Some locomotive superintendents or chief mechanical engineers have always been of the opinion that the additional complication which usually accompanied compounding was not justifiable, so far as their conditions were concerned. Others, e.g., J. G. Churchward, came to hold this view after trying compound locomotives. Compounding was given what appeared to be a new lease of life with the introduction of high pressures in the 1920's and 1930's, but it has now passed from the scene as far as new construction is concerned. Some of the designs were very successful, taking into consideration the relevant factors (which in this case included the mentality of enginemen), and the compound locomotive attained its zenith in France where the work performed in an effortless manner, usually on very indifferent fuel, was frequently of a very high order. Outputs of 39·5 i.h.p. per ton of locomotive weight are on record.

Ultimately, compounds were limited by the size of the low-pressure cylinder—the largest known to the writer was one of 48 in. diameter on a Mallet locomotive on the Virginian Railway —and the problem of getting steam in and out of a cylinder of such size. It will also be appreciated that weight became an important consideration. The problems were partly solved by M. Chapelon in his 2-12-0 design built in 1946. This locomotive had two high-pressure and four low-pressure cylinders. While such an arrangement overcame some of the difficulties, e.g., cylinder and port sizes, it added to the complication and hence to the first cost and maintenance. Apart from Mallet compounds, where the disadvantages are of less account and the increased thermal efficiency, of the order of 2 to 3 per cent., becomes worth while, compounding only survived under the enthusiast.[69]

To be continued

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ENGINEERING CONTRACTS

13—DISPUTES BETWEEN THE PARTIES

By F. H. B. Layfield

This article, the thirteenth, marks the conclusion of the series which has been contributed by Mr. Layfield for the guidance of engineers and others engaged on the preparation of engineering contracts. The twelfth article appeared in ENGINEERING, *December* 21, 1956, *page* 777.

These articles are being reprinted in book form and copies will be available very shortly, price 8*s.* 6*d., post free. Orders, accompanied by the required remittances, should be sent to the Publisher,* ENGINEERING, 35 *and* 36 *Bedford-street, London, W.C.*2.

However carefully an engineering contract is drafted there are bound to be occasions when disputes will arise between the parties, either about the contract or the execution of works under it. These disputes almost inevitably cost money and involve the expenditure of time and effort on the part of some people who might otherwise be doing more useful work. This time and effort has to be paid for, and, in the last analysis, the cost goes on to the price of the product.

Clearly, it is in everyone's financial interest, if for no other reason, to avoid disputes where possible, and to limit their extent when they cannot be avoided. Undoubtedly, the best way in which to reduce the number of contract disputes is to see that the contract is carefully and intelligently drawn. The draftsman must do his part, but he cannot make bricks without straw; he cannot put into legal form arrangements and intentions which have not been clearly formulated. The more clearly the engineer can formulate his wishes and intentions the better will the contract be. But, after all, some disputes are bound to arise. The problem then is how best to deal with them.

Perhaps the most important thing that can be done is to recognise the existence of a dispute at the earliest possible moment. Disputes are in one sense a disease; if detected and treated sufficiently early they can often be halted before they become too serious. Early recognition also has advantages even should the dispute ultimately form the subject of proceedings, for prompt detection may mean that the evidence about the dispute will be much clearer than it might otherwise be. Moreover, it is of the first importance that an attempt should be made at the earliest practicable moment to ascertain the *precise* cause of the argument. This not only involves establishing the actual facts of the problem but of discovering exactly what provision of the contract is said to have been infringed or misinterpreted.

COLLECTING EVIDENCE

It is not only the cause of a dispute which should be ascertained as it will also be helpful to make an attempt to value the damage which has occurred as soon as possible after the trouble has arisen. If and when a dispute becomes the subject of formal proceedings, it will be necessary to state explicitly what the parties say are their contentions; that is, to recite the facts and to point explicitly to a provision of the contract on which their reliance is placed. An early attempt to formulate these views will help to settle some disputes and can much assist the subsequent management of cases which are fully argued. The engineer is the right person to begin this important process. Quite frequently, a dispute commences at the very moment when he is busily engaged in supervising works of much complexity. There is a natural and real danger that, in the general hustle of his work, he will fail to stop and take an objective view of the problem. He may find it helpful, therefore, to put his appreciation of the problem on paper at the earliest practicable moment.

If and when it becomes clear that a dispute cannot easily be settled the question of evidence at once becomes important. The majority of engineering cases turn, in whole or in part, upon the facts of the matter and these often prove quite surprisingly difficult to establish when the case is heard. Engineers should remember that a dispute which goes to the Courts, or to arbitration, may sometimes not be heard until a long time after the relevant event happened. It may well be that the hearing may take place a year or more after the trouble has occurred. Memories are surprisingly short and much valuable evidence can be lost during this waiting period. Every effort should be made, therefore, to record the facts surrounding the dispute before these details are partly or wholly forgotten. This need for an accurate record is especially marked as regards oral transactions. If any verbal orders were given, or if any telephone discussions or interviews occurred, and these are relevant, they should be the subject of a report or statement as soon as may be after the events they concern have taken place. Similarly, clear evidence of the state of affairs prevailing at the time the events happened is also useful. Sometimes photographs, drawings or sketches made at, or near to, the relevant time may be useful; these illustrations should, of course, be annotated with the relevant details of date, time, light and so on. In deciding what is wanted the engineer may well try to put himself in the shoes of an arbitrator a year ahead and endeavour to visualise what would be needed to convince him, remembering always that the arbitrator will require to have all the relevant matters proved to his satisfaction.

EXAGGERATION OF DAMAGE

In many cases, expert evidence will be needed in due course, and, in such instances, the earlier the witness can be selected and set to work the better. He should be shown all the relevant documents, especially the contract documents, and furnished with all the material information at the engineer's disposal. When he has seen the site and considered the information available he should be asked to report in writing. Among many other things, he should be asked to state exactly what damage he considers has been caused by the breach of contract and should place a specific value on the damage concerned.

At this stage, there may still be opportunities to settle the dispute. The engineer and the expert witness, if any, should, therefore, be on their guard against exaggeration. Quite natural enthusiasm, indignation or plain error may cause too high a figure to be placed upon the damages which the employer may, if he is wrongly advised, decide to claim. Such exaggeration can have several serious effects upon future events. For example, it can cause reasonable offers of settlement to be refused, with subsequent and unnecessary trouble and cost to all concerned. Again, when the dispute is finally heard, exaggerated claims are unlikely to impress or mislead either a Judge or an arbitrator, and the presentation of such claims may lead to the employer being penalised to some extent in costs.

SCHEDULE OF CLAIM

One of the most helpful things which can be done, when the employer decides to pursue his claim and a settlement seems to be impracticable, is to prepare a comprehensive schedule. The schedule may take many forms but it should always set out certain specific matters. The document should state each item of the proposed claim separately, show what items in the bills of quantities and specification are involved, and what clause or clauses in the contract are concerned. Above all, the schedule should state what work has, and has not, been done against each of the items of the claim and should show the estimated loss concerned, indicating how the latter has been calculated. It will often be found in making the schedule that some items of the claim cannot be substantiated and ought to be omitted, while others may be added. When the schedule has been completed, it will be much easier for all concerned to discern the exact strength of the proposed claim and to decide upon subsequent steps.

Engineers and employers alike will be wise to bear always in mind that the costs of engineering contract cases are almost invariably heavy. Unless the claim is a large one, the legal costs, even in an arbitration, may be larger than the sum of money in dispute. Accordingly, every offer of settlement of any dispute should receive very careful consideration. Yet, even so, there are bound to be many cases where it is rightly felt to be essential to pursue the claim. The question which then arises is whether to proceed to litigation or to arbitration.

ARBITRATION PROS AND CONS

Arbitration is much more popular as a means of dealing with engineering disputes than litigation, and practically all the printed forms make provision for arbitration. In theory, its advantages are that, as compared with litigation in the Courts, it is cheaper, quicker and more convenient. The arbitrator is almost invariably a man with considerable technical knowledge and he is entitled to use this general technical knowledge in hearing a case. This usually has the result that the evidence necessary to establish the facts can be given more easily and more quickly since less has to be explained to the arbitrator than to a Judge. In practice, however, for a variety of reasons, arbitration is seldom any cheaper than litigation, rarely any quicker, and often has little to commend it save lack of publicity. It should also be remembered that where any technical issue is before a Judge, whether in the County Court or the High Court, that issue may be referred to a referee, leaving the legal issues to be dealt with by the Judge. In many disputes, this latter course is often the most expeditious, effective and inexpensive way of handling a technical case.

The nature of the action which is to be taken in the event of a dispute arising should normally be decided upon when the contract is drawn. The most common provision in a contract is that which *requires* any dispute to be referred to arbitration. Perhaps the best of these standard clauses is that set out in the " B3 " form issued by the Institutions of Mechanical, Electrical and Consulting Engineers. Clause 37 of that form states that

> " If at any time any question dispute or difference shall arise between the Purchaser or the Engineer and the Contractor, either party shall, as soon as reasonably practicable, give to the other notice in writing of the existence of any such question . . . specifying its nature and the point at issue, and the same *shall* be referred to the arbitration of a person to be agreed upon, or failing such agreement, to some person appointed . . . by the President for the time being of the Institution named in the Appendix . . ."

LORD SIMON'S JUDGEMENT

If a provision of this kind is embodied in the contract, the parties are *not* at liberty to go to the Courts instead, except in certain instances. The position of the parties was described by Lord Simon in the House of Lords when giving judgement in the case of *Heyman v. Darwins Limited*:

> " An arbitration clause is a written submission, agreed to by the parties to the contract, and, like other written submissions to arbitration, must be construed according to its language and in the light of the cir-

cumstances in which it is made. If the dispute is whether the contract has ever been entered into at all, that issue *cannot* go to arbitration under the clause, for the party who denies that he has ever entered into the contract is thereby denying that he has ever joined in the submission. Similarly, if one party to the alleged contract is contending that it is void *ab initio* (because, for example, the making of such a contract is illegal), the arbitration clause cannot operate, for on this view the clause itself is also void. But, in a situation where the parties are at one in asserting that they entered into a binding contract, but a difference has arisen between them whether there has been a breach by one side or the other, or whether circumstances have arisen which have discharged one or both parties from further performance, such differences should be regarded as differences which have arisen 'in respect of' or 'with regard to' or 'under' the contract, and an arbitration clause which uses these, or similar, expressions should be construed accordingly."

Lord Simon went on to observe that, by English law, such a clause would also confer on the arbitrator power to assess damages for breach of contract, even though this power be not expressly stated. But he also pointed out

> "I do not agree that an arbitration clause expressed in such terms as above ceases to have any possible application merely because the contract has 'come to an end' as, for example, by frustration. In such cases, it is the *performance* of the contract that has come to an end."

RECOURSE TO COURTS

If, therefore, the employer or the engineer have any doubts about the wisdom of proceeding to arbitration, in the event of *any* dispute, they should consider these aspects when the contract is framed. Once they have agreed upon a clause such as that quoted above, they will have no option but to proceed to arbitration (except in the special instances mentioned by Lord Simon). It will be necessary to go to arbitration even if, in the event, the actual dispute is thought to be more suited to the Courts, unless the other party can be brought to waive his right to arbitration.

The story, does not, however, necessarily end with an arbitration. There are two remedies remaining. In the first place, no arbitration agreement can oust the jurisdiction of the Courts. As Lord Justice Denning has said, the parties to a contract

> "can, of course, agree to leave questions of law, as well as questions of fact to the decision of the . . . Tribunal. They can, indeed, make the Tribunal the final arbitrator on questions of fact, but they cannot make it the final arbiter on questions of law. They cannot prevent its decisions being examined by the Courts. If the parties should seek, by agreement, to take the law out of the hands of the Courts and put it into the hands of a private tribunal, without any recourse at all to the Courts in case of error of law, then the agreement is to that extent *contrary to public policy and void* . . ."

In addition to this right to have any question of law referred to the High Court, usually by means of case stated, there is a right, with leave, to appeal from the High Court decision to the Court of Appeal.

The result of arbitration provisions is often such that matters best heard by the Courts are first heard by an arbitrator and then, in turn, considered by the Courts. Perhaps the most sensible arrangement is to provide in the contract that disputes which concern facts, or mainly concern facts, should go to arbitration, while those disputes which are wholly or mainly about the law should go to the Courts. It can then be left to the Courts to decide which is the appropriate procedure, should the parties be unable to agree which kind of dispute is involved. The latter provision need cause no concern since the Courts have power to refer technical issues, should there be any, to a referee if this course should seem desirable.

WHEN TO REFER

Once a decision is taken to refer all, or any disputes, to arbitration, it is useful to settle two questions. The first matter to decide is when the reference to arbitration may take place. Some contracts provide that a dispute may be referred to arbitration as soon as it occurs, as in the "B3" form quoted above. Other contracts do not permit reference until the work has been completed. There are advantages, no doubt, to the latter arrangement, but it should be realised that it also has dangers. To require that one of the parties to a contract shall continue to work while a grievance about that work remains unsettled is not always wise, or good for working relations; and, often, it has, in practice, even more serious effects. The inability to have a dispute heard at once may create financial uncertainty which can be so serious as to persuade one of the parties that it is better to break the contract completely rather than continue in uncertainty.

The second question to settle is what is to happen to the work when there is a reference to arbitration. Such a problem only arises, of course, where a reference can be made before completion of the contract work. Here again, the "B3" form makes wise provision, by requiring that

> "Performance of the contract shall continue during arbitration proceedings unless the Engineer shall order the suspension thereof . . . and if any such suspension shall be ordered the reasonable expenses of the Contractor occasioned by such suspension shall be added to the Contract Price."

The "B3" form also lays an important duty on the purchaser, in this connection, by requiring him to see that

> "No payments due or payable by the Purchaser shall be withheld on account of a pending reference to arbitration."

SUMMARY

Disputes are expensive and inconvenient; they are to be avoided wherever possible. Quite a considerable effort is warranted to settle disputes and so to render unnecessary the expensive, lengthy and elaborate proceedings which might otherwise be involved. Early and thorough efforts to define a dispute exactly, to trace its cause and to calculate the precise damage involved should be made. These efforts are likely to enable the employer and engineer to decide objectively what action will be the wisest one for them to take. Early appreciation of the extent and nature of a dispute makes a reasonable settlement more likely. At the same time, such early preliminary work makes a valuable foundation for any proceedings which may ultimately take place. In particular, an early record of the facts of any dispute are especially helpful; and any expert witness who will be needed should be brought into the case at the earliest possible moment.

The engineer ought not to take it for granted that, if a dispute cannot be settled, the best course is to go to arbitration. For some disputes arbitration is undoubtedly the best course, but, in other cases, much time, irritation and expense could be avoided by going to the Courts in the first place. Many such disputes end in the Courts anyway and much of that which happens beforehand merely helps to increase the expense. These possibilities should be borne in mind when the contract is drawn, for once an agreement has been made to go to arbitration over any dispute, the parties will be obliged to do so, except in the case of certain limited exceptions.

The agreement to go to arbitration must not exclude the jurisdiction of the Courts or it will, to that extent, be void. Thus, there is always a right to go to the Courts from an arbitration on a point of law. If there is to be arbitration, it is desirable also to fix when reference to the arbitrator may take place and, where applicable, what is to happen to the work while such proceedings are pending and in progress.

Whether disputes go to arbitration, or are taken to the Courts, or, as all too often happens, both these processes are resorted to, the result is likely to be expensive. Many cases are heard which could have been settled had the parties appreciated at a sufficiently early date either the exact nature of their case or the costs which a legal argument might incur. With respect to the majority of disputes, considerable efforts, and even sacrifices, are worth making to avoid formal proceedings.

* * *

AIR POLLUTION

A Dreadful Indictment

The total cost of air pollution in Britain is estimated at £250 million a year. This appalling figure takes no account of the cost of the wasted fuel which goes up in smoke. It includes only the damage to property by corrosion and dirt; wasted work such as washing, redecoration, medical attention, etc.; injury to health, mainly in the form of bronchitis; and loss of working days or efficiency at work through ill-health. Excluded, because it cannot be measured, is the reduction in the value of life through squalor and incalculable destruction of art treasures. That the cost of pollution was high was widely supposed but here is an attempt to measure it that is new—and an apportioning of the blame. A rough estimate of the damage done per ton of fuel consumed by the various classes of consumer is as follows: domestic, £6—equivalent to not much less than three-quarters of the cost of the fuel consumed; road traffic (oil), £1·6; railways, £0·7; collieries, £0·23; industry, £0·16; electricity, £0·03; and others (coal), £0·35.

These estimates are given in a paper read to the Institute of Fuel by Dr. R. S. Scorer, of the department of meteorology, Imperial College of Science and Technology, London. He points out that his conclusions are rough but "are thought to be substantially correct." They have been made for the country as a whole and cannot be applied to particular areas without modification. This is an awful thought for the inhabitants of London, Birmingham, Glasgow, Manchester and other large towns. The aim of the investigation was to indicate remedies that might be applied by large users of coal: "That the outcome would amount to a dreadful indictment of domestic coal consumption was not foreseen." The investigation showed that combustion in domestic grates is generally very incomplete. The gases are relatively cool because of entrained air, and are emitted at about roof level. They contain unburned volatile components of the fuel that are tarry, corrosive and dirty, and some ash. The saving to the nation from the universal use of smokeless fuel in domestic grates would be between £100 million and £140 million a year.

The results of Dr. Scorer's work are both alarming and shocking. They will doubtless be challenged. He himself emphasises that much research needs to be done before accurate estimates can be given. But his approximation is enough to show that urgent action is required. It also shows that the rapid spread in the use of Diesel vehicles is dangerous unless an effective exhaust-gas filter is devised. The encouraging feature of his paper is that the damage caused by the generation of electricity is very small: "Gas washing at power stations costs far more than the damage it prevents." In general the higher the combustion efficiency the lower the damage. We have it in our power to eliminate the major sources of pollution and in so doing to save vast quantities of fuel. The social cost alone of doing nothing is more than enough to warrant the use of legislation and public funds to take the necessary measures without delay.

SCIENTIFIC RESEARCH IN AUSTRALIA

The agricultural and pastoral industries are still predominant in Australian economy, and with the associated industries of fisheries, food preservation and the exploitation of water resources and of hitherto undeveloped land areas and the study of such matters as pestology constitute the main concern of the Commonwealth Scientific and Industrial Research Organisation. The Seventh Annual Report of the Organisation, obtainable (price 11*s.) from the Commonwealth Government Printer, Canberra, presents an account of the research during the year ended June* 30, 1955, *sponsored by the Australian Government primarily on behalf of the Commonwealth industries but including also investigations into subjects such as primary standards, meteorology and extraterrestrial physics, that can be properly undertaken only on a national scale. The work described represents an expenditure of close on* £5½ *million.*

Research of more direct engineering interest is in active progress to develop Australia's minerals, among which uranium ores are nowadays of special importance. Leaching techniques suitable for the extraction of uranium in different localities are under development, emphasis being on continuous, as distinct from batch, processing. With the same general objectives, similar mineragraphic and chemical extraction studies are in progress relative to ores containing gold, copper, cobalt, titanium and a variety of rarer metals of industrial importance. Much attention is also directed to the treatment and utilisation of Australian coals, one of the principal objectives being to make the most economical use of brown and low-grade coals by gasification. A high-pressure reactor for carrying out studies on the hydrogenation of brown coal, installed in a laboratory of the Division of Industrial Chemistry, is seen in Fig. 1.

Contrasting with these long-term investigations is a project for the development of flat plate solar absorbers intended, at present, for domestic water heating. Several experimental heaters have been installed near towns where their performance can be readily observed, and improved designs are in hand for more ambitious permanent installations. At present prices, the capital cost of a solar domestic water heater is considerably greater than that of a comparable electric appliance. The design of the radiation absorber is now being simplified to facilitate manufacture, and it is hoped that the resulting cost saving may prove to be quite substantial.

A typical flat-plate solar water heater for domestic applications, having an absorbing area of 45 sq. ft., is shown in Fig. 2.

FOUNDRY AND BUILDING MATERIALS

Chemical research is also being directed to foundry sands, emphasis being given to the use of Australian bentonitic clays as substitutes for imported bentonite in the preparation of synthetic moulding sands. The chemistry of other refractories, ceramics and cement justifies a great deal of laboratory work, the fundamental studies of cement, gypsum plaster and lime products being associated with a variety of mechanical and field-test work conducted by the Division of Building Research. One such investigation, designed to explore the stress/strain conditions governing the fracture of concrete, has established that micro-cracks develop in loaded specimens of un-reinforced concrete at smaller loads than that responsible for ultimate failure. No relationship between cracking load and ultimate load has yet been ascertained. Strain measurements on concrete beams maintained under 90 per cent. of their ultimate load for nearly a year have shown that the creep of concrete is considerably higher in tension than in compression.

Somewhat similar loading tests, on prestressed concrete beams, are in hand to examine the stress losses in the prestressing wires and the mechanism of eventual failure. An interesting minor investigation has been concerned with the employment of gamma radiation from cobalt 60 to measure the densities of building materials. Experiments covering a variety of materials have established a correlation between the transmission of the radiation and the density over the range from 20 to 150 lb. per cub. ft. This technique offers the advantage of permitting densities of materials *in situ* to be measured, and the progress of construction, in that respect, to be controlled.

METROLOGY AND STANDARDS

Three divisions of research under the Organisation, concerned respectively with metrology, physics and electro-technology, together comprise the Australian National Standards Laboratory with headquarters at Sydney. Their special function is the realisation and maintenance of the primary standards of length, mass, temperature, illumination and the fundamental electrical quantities. To these have recently been added certain nuclear standards such as the energies of alpha particles from some natural radioactive substances, and the gyromagnetic ratio of the proton. The former are of importance in

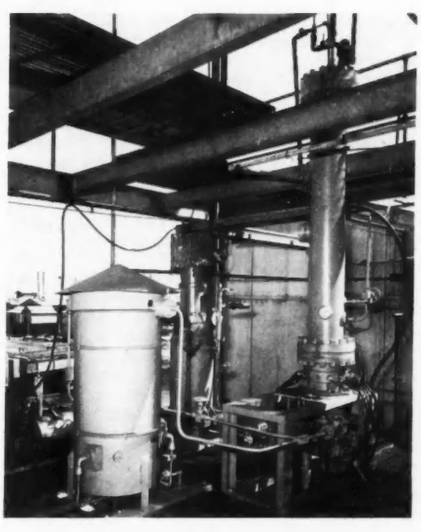


Fig. 1 High-pressure reactor for studying the hydrogenation of brown coal.

providing energy standards for nuclear reactors, while the second serves as a standard for the precise measurement of magnetic fields. An alternative technique for measuring steady magnetic fields in the range from 10 to 4,000 oersteds has also been developed. A very small ring of soft iron is placed with its axis parallel to the field under investigation and is magnetically saturated twice per cycle by a 50-c/s current flowing in a wire through the centre of the ring. The resulting alternating magnetic flux parallel to the unknown steady field is a measure of the latter and is detected by a coil wound over the ring.

Noteworthy among the many investigations carried out by the Standards Laboratory, on behalf of industry, are the design of electronic equipment for measuring periodic errors in machine tools, and the study of the influences of various factors in the high-speed routing of aluminium alloys. This last-named problem arose because single-fluted carbide cutters, at a cutting speed of 3,000 ft. per min., failed prematurely and left a poor finish on the work. As the outcome of experimental variation of the number of flutes, and the geometry and material of the tool, a cutter having a much longer working life and giving consistently good results has been evolved. To meet demands for the verification of materials-testing machines, two 300,000 lb. capacity proving rings have been acquired and a new Brinell machine is in use for calibrating hardness test blocks. In the measurement of Brinell impressions by a microscope having vertical illumination, the image of the impression appears dark on a bright field and, if the objective is of low power, the deformed rim of the indentation may cast a peripheral shadow that can easily be mistaken for the edge of the impression, and give rise to gross errors in the hardness number. To surmount this defect of vertical illumination an oblique illuminator has been developed which facilitates inspection of the impression as well as increases the accuracy of diametral measurement.

The industrial application of metrological techniques is further exemplified by a novel method that has been developed for measuring and analysing the geometric errors of a watch. The watch is mounted concentric with a disc which rotates at the same speed as the sweep hand of the watch. Directly above the sweep hand is a radial slit in the disc through which the watch dial is photographed, the duration of the exposure being equal to the period of rotation of the hand. Thus a record is obtained of the stationary position of the hand corresponding to each graduation, thereby enabling the error in reading at each graduation to be determined. From the pattern of the errors it is often possible to identify their source. Also of interest is the recent manufacture of some standard weights, in denominations greater than one kilogram, from aluminium bronze. This material was chosen as an economic alternative to stainless steel for large weights since it has good corrosion resistance and antimagnetic properties, but its long-term stability must be the subject of comparative trials against primary standards over a number of years. New equipment for measurements on the International Temperature Scale includes a steam-point apparatus that gives temperatures reproducible to 0·0002 deg. C., and cells for realising the triple point of water which gives a stable temperature accurately reproducible to 0·0001 deg. C. The value of these cells derives from the redefinition, by the 10th General Conference of the International Committee of Weights and Measures in 1954, of the thermodynamic scale of temperature in terms of the triple point of water (273·16 deg. K.). This temperature is close to that of the melting point of ice but in practice is capable of measurement with considerably more certainty.

METAL PHYSICS

Research in tribophysics has included some experiments on lubricated plain bearings to

Fig. 2 A flat-plate solar water heater for domestic applications having an absorbing area of 45 sq. ft.

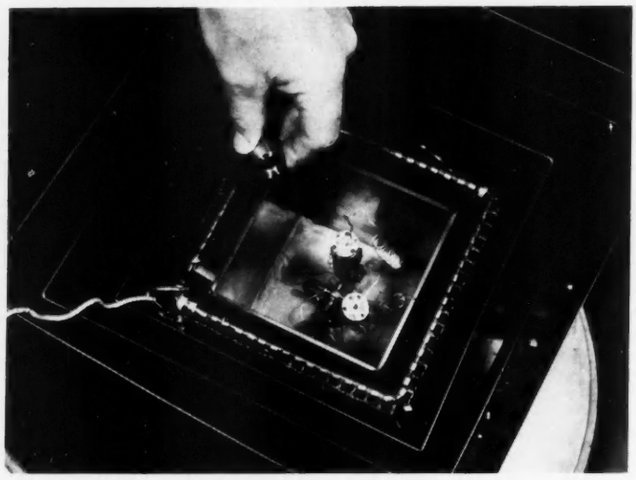


Fig. 3 Interior of vacuum calorimeter used for measuring the energy stored in deformed metals, showing two specimens in position. A third specimen is held to illustrate its shape.

appraise the effects of the surface finish of the journal, the diametral clearance and the precision of the assembly, on the performance of the bearing during running-in and in subsequent service. The conclusions are that a very smooth journal is conducive to rapid running-in, and that if the whole assembly is manufactured and assembled with accuracy, bearings having very small clearance run-in most rapidly and give high ultimate performance.

Basic research in metal physics has led, during the year to the experimentally-confirmed conclusion that at least three mechanisms may operate in the liberation of stored energy during the heating of a deformed metal. These are the disappearance of vacancies in lattice sites, the recovery of a proportion of the original energy of deformation involving the re-arrangement or annihilation of dislocations, and recrystallisation accompanied by the disappearance of the remaining excess of the dislocation caused by deformation. The manner in which the energy associated with these processes varies with the amount of deformation has been studied for nickel, arsenical copper and pure copper. In the case of pure copper, deformed by static torsion or compression, recrystallisation is responsible for almost all the release of stored energy. If, however, copper is deformed by fatigue, a measurable quantity of energy is stored, for instance, during alternating tension and compression; but the manner in which such energy is released during subsequent heating differs from that for other types of deformation.

A piece of apparatus used for measuring the energy stored in deformed metals is shown in Fig. 3. In Fig. 3 is seen the interior of the vacuum calorimeter employed in which two specimens are in position for a test. A third specimen is shown to illustrate its shape and to give an idea of its dimensions.

EXTRA-TERRESTRIAL PHYSICS

A group of researches for which the Organisation deservedly enjoys an international reputation is directed to extra-terrestrial physics, which can be said to range from meteorology to the exploration of outer space by radio astronomy. At the inner end of the scale the study of cloud formation, especially in its relationship to the artificial promotion of rain, is of such potential importance to the economy of Australia as fully to justify the experiments that have been in progress, for a number of years on the " seeding " of appropriate forms of clouds with finely divided solid carbon dioxide or silver-iodide smoke. The results of this work have led to a clearer understanding of the part played in rain formation by minute particles of dust or sea spray that may be naturally present in the atmosphere, and which may act either as condensation nuclei for warm clouds or as freezing nuclei for supercooled clouds. In the pursuit of these studies, a team of Australian scientists has participated in a project, sponsored by the Boston Oceanographic Institute, during which various measurements, such as the temperature, water content and electrostatic charge of clouds, were made from an aeroplane in flight over Hawaii. Associated experiments have been concerned with recording photographically the movement of water droplets in a strong electric field, and with analysing the connection between rainfall and meteor activity. Optical investigation, by a scattered light method, of the dust content of the upper atmosphere has indicated the presence of dust accumulations related to meteor streams at altitudes of up to 80 kilometres. There is, statistically, a marked tendency for excess rainfall to occur about 30 days after the date of known meteoric activity, and it is thought that this interval represents the time taken by meteoric-dust particles to fall to the lower regions of the atmosphere where they could induce rainfall by acting as freezing nuclei.

RADIO ASTRONOMY

At the other limit of extraterrestrial physics, in the field of radio astronomy, several important discoveries concerning the sun and the galaxy have been made by the use of new types of equipment designed and constructed within the organisation. Outstanding among these devices is the " Cross " aerial which has such a high degree of directivity, when used at a wavelength of 3·5 m., that many celestial radio sources have been, for the first time, resolved from their surroundings. The distribution of radio emission from the Magellanic Clouds, for example, has been studied in such detail that the separate emissions from the various stellar populations in a galaxy have been compared. From these and similar observations on other galaxies and selected parts of the Milky Way, it appears that the principal radio emission from a galaxy originates in two different types of source and is produced by high-energy electrons moving in magnetic fields in interstellar space. A second, larger Cross aerial system, designed to operate at 15 m. wavelength, is under construction. It will have arms nearly 4,000 ft. long and a beam width of about 1·5 deg. Spectral observations of solar radio bursts are being used to determine the character of corpuscular streams from the sun. They support the suggestion that the fastest of those streams represent the cosmic rays of solar origin which bombard the earth about an hour after a solar eruption. In the search for evidence of radio emission from the planet Jupiter, strong signals like those from atmospherics have been detected intermittently. The directional accuracy attainable with the present equipment is not high enough to exclude the possibility of an origin in a source other than Jupiter, but the observations lend powerful support to the idea that at least one member of the solar system, in addition to the sun, emits radio waves.

These notable discoveries are a foretaste of what the Australian astronomers may be expected to achieve when they acquire the means of exploring the entire galaxy at the shorter wavelengths. This calls for the use of a very large radio telescope, capable of being directed to any point within a wide angular area, and of following the movement of the celestial sphere. A highlight of the year covered by the report is the gift, by the Carnegie Corporation of New York, of 250,000 dols. towards the cost of such an instrument for Australia. The Commonwealth Government has offered to defray half the total cost provided the remainder can be found from other sources. From the number of such donations already received or promised, the requisite financial support is assured and the Organisation looks forward with confidence to making an increasingly valuable contribution to the development of an exciting new science.

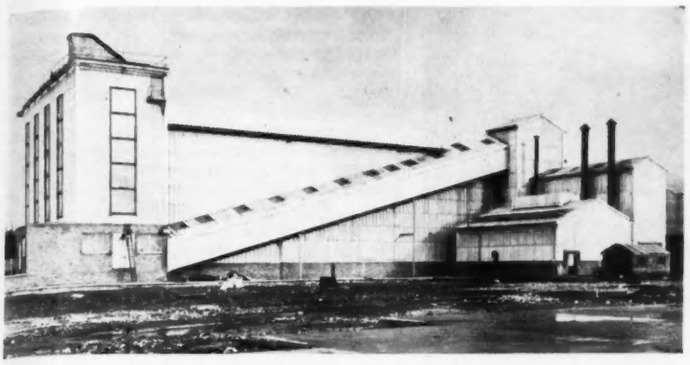
* * *

THE SCIENCE THAT MIGHT BE TRANSPORT ENGINEERING

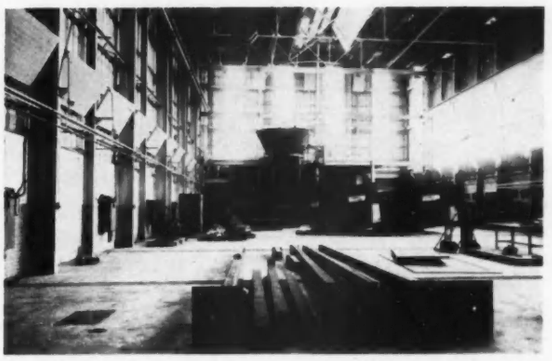
" Man must measure " is the title of a paper recently read by Sir Charles Goodeve, director of the British Iron and Steel Research Association, to the Institute of Transport. It is a plea for the use of scientific method in measurement, sometimes known as operational research. Sir Charles believes that scientific analysis, through observation and measurement, can yield great benefits in the operation of road transport. The main problem, he considers, is that of assessing the value of investment in new roads and in road improvements in order that these may be compared with the investment in other directions. The same theme was dealt with by P.E.P. in a broadsheet reviewed in Weekly Survey on December 7. Sir Charles sketches a model, or " fundamental picture," of a transport system in order to indicate those things that need to be measured in order to achieve improvements which can be related to their cost. The precise calculation of benefit-to-cost ratios is indispensable if a correct choice is to be made of the road improvements likely to yield the quickest returns. " I believe that the policy in recent years of allocating most of our limited road funds to maintenance, instead of towards improving efficiency, is due largely to the scarcity of people studying the science of transport."

Two examples of the application of scientific measurement are given in the paper. The first is of the accidents attributable to defective rear lights. The general belief was that this was a very minor cause, until the Road Research Laboratory carried out a thorough inquiry. A vehicle built before the war was found to be six times more likely to be run into from behind than a vehicle made after the war. " The only relevant difference was that nearly all cars built since the war had rear-lights many times brighter than those built before the war (in order that cars could be sold in America)." Since the rear light was almost invariably damaged in the accident the police could not testify to the effect that it was faulty and another cause was recorded. The second example concerns traffic intersections. Sir Charles concludes that these should be several times wider than roads leading into them; the benefits to be derived are such that the higher cost of land acquisition and construction work, though higher than anywhere else, is insignificant in proportion. The fact that traffic is thickest in such places was known to the merchants who crowded the Ponte Vecchio in Venice to slow pedestrians down to a " purchasing pace."

Sir Charles's stimulating paper will appeal strongly to those who have the scientific outlook and like to get a problem down to its basic elements. He goes far to establish that this is the only way to effect road improvements at reasonable cost to the community. It may be that his assertion that " civilisation consists of meetings and indeed its level can be measured by them " will be invalidated by the growth in telecommunications, both sound and vision. But this will take more time than we can afford.



The conveyor supplying fuel to the heating boilers of the N.C.B.'s Central Engineering Establishment can also be used to elevate coal to the top of No. 2 laboratory, for testing plant erected there.



One of the two principal engineering laboratories is designed for testing coal-preparation plant. It is a lofty building, enabling complete plants to be erected.

DEVELOPING COAL MINING EQUIPMENT

ENGINEERING FACILITIES FOR THE N.C.B.

The National Coal Board's Central Engineering Establishment at Bretby, Burton-on-Trent, which is now in commission, provides facilities which have not hitherto been available to the coal mining industry. The function of the Establishment is, briefly, to develop existing mining equipment, to design and produce prototypes of new equipment and components, to be responsible for testing mining machinery and equipment of all kinds, and to evolve standards and methods of testing. The Establishment is not concerned with the manufacture of equipment in quantity, and it is intended to co-operate with British manufacturers of mining machinery in this respect. Prototype development will also be carried out to a considerable extent in co-operation with manufacturers. The Establishment works in very close collaboration with the National Coal Board's two research establishments on a two-way basis, receiving ideas already brought to a stage requiring development, and referring back work on which more fundamental research is required. Contact is also maintained with other departments of the Coal Board, with industry and with other organisations, so that ideas worthy of development can be investigated, and so that the greatest possible help can be given to mining engineers in solving their engineering problems.

The building of the Central Engineering Establishment was originally authorised by the Board in 1952, and a central site was chosen at Bretby. Designs were prepared by Maunsell, Posford and Pavry, 75 Victoria-street, London, S.W.1, and the main building contract was let to George Wimpey and Company, Limited, Hammersmith-grove, London, S.W.6. Work commenced in June, 1954, and by the end of 1955, after some delays due to bad weather, the Establishment was partly in operation. The major part of the work of building and equipping the Establishment is now complete, and a very large programme of development work is in hand.

The Establishment is under the control of a director, who is himself an engineer, and is directly responsible to the Board's chief engineer at headquarters in London. There are six departments, five of which are concerned with engineering matters, while the sixth is responsible for administration and finance. The work of the departments can be summarised under their respective titles. The development engineering department is concerned with the design and development of electrical and mechanical equipment used in the mining industry, the preparation of specifications, the direction of development trials in the field, liaison with outside manufacturers, liaison with N.C.B. and other research establishments, and the provision of an engineering advisory service to the industry. The work of the project department is indicated by its title, but it might be added that the department is responsible for the appraisal of proposed projects, as well as for the design and analysis of such projects, the formulation of technical specifications and preparation of designs, and the control of the design and drawing offices.

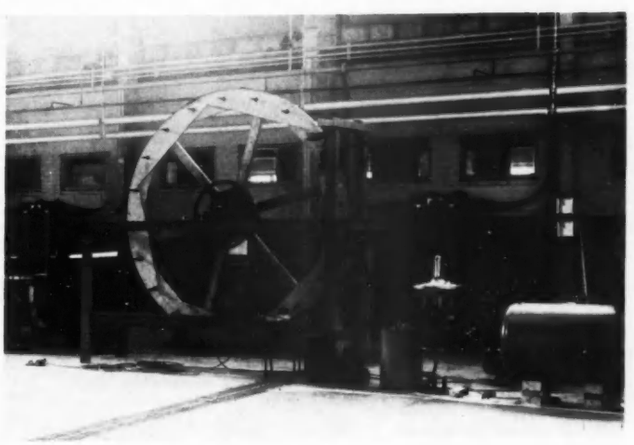
The proving and acceptance department has as its primary function the control of quality of machines, materials and equipment used by the Board throughout the country. To this end the department co-operates with the users of equipment to determine what tests are appropriate, and conducts tests in the field, in the laboratory, or in both according to circumstances. Developments in specialised or non-traditional fields are the responsibility of the special projects department. Coal preparation, certain aspects of ventilation, power stowing and pumping are among the matters handled by this department. The engineering workshops of the Establishment form a separate department, which is responsible for providing general engineering services for constructing prototypes and test rigs, modifying existing equipment, general maintenance of the Establishment, and supervision of the engineering stores. These five departments, which co-operate as required, are each headed by an engineer, who is responsible to the director.

Commercial matters, including administration, finance, supplies, staffing, statistics and secretarial work, are the responsibility of the administration and finance department which, like the other five, has a head who is directly responsible to the director.

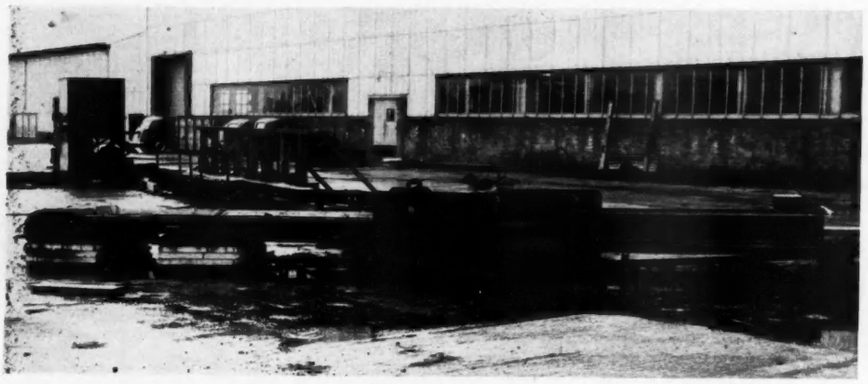
An administrative block houses the staff and clerical offices, lecture theatre, conference rooms, drawing offices, library, and other commercial and technical offices. Behind this block of buildings lie the workshops, engineering laboratories, ancillary and service buildings, including the canteen, and a large open area where equipment too large for the workshops can be assembled and tested. The Establishment also controls an open-air test ground at Swadlincote, about four miles away, where a 3 ft. gauge rail track is being laid over a course of about 1½ miles. There will be several gradients and a number of level sections, and it will be possible to conduct a large range of tests on locomotives, mine cars and track fittings. Part of this test area is also being prepared for experimental work on conveyors at different gradients.

The workshops at the Establishment are designed for general-purpose engineering, versatility being the keynote, and all the machine tools are of orthodox design. Equipment is provided for shearing, roll-bending and folding of plate up to 6 ft. by ⅜ in., flame cutting up to 8 in. thick, and bending and shaping rolled sections. Both gas and electric welding equipment are available, and there is a 3 cwt. hammer for light forging work. The machine tools include four centre lathes up to 18 in. swing, and a 1½ in. bar capacity capstan lathe. Two radial drilling machines and a two-spindle driller deal with drilling up to 2½ in. diameter and tapping up to 1¼ in. diameter. Planing up to 8 ft. by 3 ft. by 3 ft. can be undertaken, together with shaping, slotting, milling and boring. The machining facilities will be augmented by other machines now on order. A tool service section is fully equipped to deal with the maintenance of the small tools.

An area of 100 ft. by 26 ft. immediately adjoining the machine tool section is provided for fitting, assembly and stripping of machinery;



A typical medium-sized piece of equipment under test is this experimental blow-off timer, designed to ensure clean discharge of filter cake.



It is not practicable to erect every piece of mining equipment for test in one of the laboratories, and a large open-air erection ground is therefore provided.

an overhead electric travelling crane, controlled from the floor, serves the machining and assembly areas. Portable power tools and an electric welder can be used from power points covering the whole assembly area, and there is a 2 in. diameter capacity portable radial drilling machine for use on equipment which cannot be taken to the fixed machines. A separate section of the workshops is equipped for wood working, and can undertake the manufacture of scale or full-sized models and maintenance work for the Establishment.

TESTING PROTOTYPES

Equipment made or modified in the workshops, purchased from outside suppliers, or obtained from other Coal Board departments can be tested in one of two large engineering laboratories, both of which are provided with overhead electric travelling cranes. Adjoining laboratories cater for test and practical development of small components and equipment which can be handled on a bench. No. 1 engineering laboratory has facilities for setting various items of mining equipment such as props, chocks, roof supports, pit arches and conveyor belts, as well as complete machines. Provision is made, either in the large laboratory or in one of the smaller adjoining ones, to carry out all the standard physical tests such as impact, hardness, tension, compression, bending and abrasion. Ultrasonic and portable magnetic flaw detectors, together with a projection microscope, cater for physical inspection.

Some of the testing work can be done on orthodox equipment such as universal testing machines, but for other work special machines or rigs are required. The determination of the fatigue life of mine-car couplings under ramming conditions, for example, requires a specially-designed rig, as does the testing of mine roof bars. The designing and manufacturing of the necessary rigs and special machines are done either in the Establishment itself, or by outside manufacturers in co-operation with Establishment engineers. An example of the latter type of work is provided by a 360 ton capacity hydraulic testing machine for pit props, which has several novel features. It was designed and built by Chatwood Milner, Limited, Shrewsbury, in co-operation with Establishment engineers.

No. 2 engineering laboratory is designed for the development and testing of new designs and methods for handling, cleaning, sizing, drying and transporting of coal, and for certain hydraulic work. It is a lofty building capable of accommodating the large settling tanks, cones and other equipment used in coal preparation. An overhead electric travel ing crane is installed. A feature of this building is that it is adjacent to the boiler house used for heating the Establishment buildings, and the conveyor which elevates the boiler fuel to the boiler bunkers is designed to be used, as occasion requires, for raising coal to the top of No. 2 laboratory building. From this point the coal can be distributed overhead to the various items under test, according to the experimental requirements.

A third engineering laboratory, which is under construction, will house a large testing machine of the horizontal type, for proof and destructive testing of winding and haulage ropes, couplings and similar items.

WORK IN HAND

The programme of the Establishment is so large and varied that it is impossible to do more than mention a few of the projects in hand. The emphasis at present is on power loading and tunnelling (though these subjects are by no means the only ones being studied), and one of the major problems being tackled is that of getting greater outputs from seams of all kinds at lower cost, and at the same time improving coal sizing. Much work has already been done, and some successful devices have been introduced. Work on power loading and conveying, which are complementary, involve both modifications to existing equipment and the preparation of completely new designs. Experiments are proceeding, for example, with a new type of drum for a conventional Anderton coal cutter, with the object of introducing an improved water spray for dust suppression. This has involved the design and development of a new cutter pick and a new locking device, both of which originated at the Establishment. A more fundamental development is a vertical drum type coal cutter which is intended for use in seams of medium thickness. This machine will be propelled by a walking jack mechanism instead of a rope haulage, and will incorporate novel features.

Conveying work includes the development of several types of face conveyor, angle stations for belt-turning, and three types of belt cleaner, for use under varying conditions. A new type of conveyor drive under test works from the troughing idlers, which are themselves driven by line-shafting and gearboxes. This method of drive can be used as the prime mover for a complete belt, or for boosting purposes in an existing installation. It has several advantages, including simplification of belt routing and the fact that belt thickness can be reduced, as the tension is much less than with a normal drive.

Various aspects of roof control and support have to be considered in conjunction with face machinery, and work is in hand on roof bolting, which is comparatively new in this country, and on completely new types of roof support.

The methods of mining likely to be used in the future will call for underground tunnelling on an increased scale, and a major project in hand at the Establishment is the development of a tunnelling machine. The cutting of tunnels by machine is not new, but the present requirement is for a machine capable of working to a diameter of 18 ft., in the hardest of coal measure rocks, at faster rates of advance than are possible by present methods. Considerable development work will be necessary, and the Establishment is working on a machine using roller type cutting and bursting tools on contra-rotating disc heads driven from four identical power units of 160 h.p. each. High thrust is needed for this type of cutter, and it is effected by reacting on the tunnel lining or strata. Steering gear is also being developed, together with special equipment for dust suppression, ventilation and cooling, roof support setting, disposal of debris, and general services behind the machine.

PROTECTING GAS-FIRED PLANT AGAINST FLAME FAILURE

THREE DESIGNS OF INSTRUMENT

During the past six years the technique of flame-failure protection for gas-fired installations has developed, particularly in the field of multiple-burner protection, and for this reason the Industrial Gas Development Committee have recently issued a review (report No. 611/56) of "Flame Protection Practice (1956)" to supersede the report issued in 1950 under the title "Flame Failure Devices—a Review of the Present Position." We give below a summary of the first section of the report; the remaining three sections are concerned with recommendations on the installation, control, and servicing of thermal-expansion devices, thermo-electric devices, and electronic devices.

A satisfactory flame-failure device for a gas-fired installation should ensure correct lighting procedure and protect the installation against flame failure from any cause. The essential characteristics are (*a*) that it should entirely prevent gas from being supplied to the main burner until the pilot flame is established; (*b*) it should be designed to fail to safety; (*c*) it should stop all gas flow to the appliance after a flame failure, and should require manual resetting; (*d*) it should be actuated only by a properly-established pilot flame sited to ignite the main burner without failure or delay; and (*e*) where it incorporates a gas-carrying component, it should have an approved capacity within a permitted pressure loss. It is also desirable that a flame-failure device should be readily maintained and protected from adjustment by unauthorised persons; it should be reasonably, unaffected by foreign matter; and it should tolerate reasonable fluctuation in gas pressure and combustion characteristics, variations in ambient temperature and air speed, and vibration and mechanical shock.

There are at present three main types of flame-failure mechanism in use—thermal expansion, thermo-electric, and electronic devices. Thermal expansion devices fall into three categories—unimetallic elements, bimetallic elements and liquid and vapour expansion elements; the latter not yet being in general use, insufficient experience is available to assess their reliability.

THERMAL EXPANSION ELEMENTS

In the unimetallic element, the heat from the pilot burner causes a differential longitudinal expansion between the two sides of a metal tube, producing a small curvature of the axis of the tube. The device is rapid in response and should not be affected by high ambient temperatures. The principle, however, is comparatively new and has not yet been sufficiently developed in the United Kingdom to give a satisfactory performance.

Bimetallic elements are inherently slow in

response; they have a limited working life and are prone to fatigue failure. They are, however, mechanically simple and inexpensive and are acceptable for appliances of limited gas rate, provided that the pilot is protected, that they are constructed so as to fail to safety—not all those in present service satisfy this condition—and that they are regularly maintained and renewed at specified periods. Two types of bimetallic element are currently in use—the rod and tube type, and the bimetallic strip or disc. The former is more robust and the outer tube can be made of, or sheathed in, heat-resisting material. The bimetallic strip is the least satisfactory element since, under direct heating, it is liable to corrosion which may result in failure to danger. Its use is therefore not recommended.

Thermo-electric flame-failure devices, comprising a thermocouple energising an electro-magnet, are slower in response than is desirable, but they are more reliable than the thermal expansion types. They are of two types, one having a gas-valve mechanism directly attached to the keeper of the magnet, and the other using the magnet to operate a relay, and requiring a suitable electric supply.

FLAME CONDUCTION AND RADIATION

Electronic flame-failure devices are the most satisfactory and reliable type at present available, having a rapid response and " fail-safe " characteristics, and providing for automatic and fool-proof ignition. They are, however, more costly and they require a 200-250 volt supply. Two types are in current use, those depending on flame conduction—liable to be unsatisfactory in dusty locations where the dust may form a leakage path—and those utilising photo-electric cells to detect flame radiation. Photo-electric devices have the advantage of avoiding all contact with the flame; because they need to be selective to radiation from the flame itself, they are used to detect the fluctuation in the infra-red radiation rather than to detect the presence of a particular wavelength. Regular inspection and renewal is necessary, as with thermionic valves. Two other properties of the flame which may possibly be used in future electronic devices are the flame's ability to effect partial rectification of an alternating current, and the flame capacitance.

MULTIPLE BURNER SYSTEMS

Concerning multiple-burner systems, the Industrial Gas Development Committee aims, ultimately, to eliminate them wherever practical. Where such systems are essential, individual protection to each burner is preferred, but at present the use of " ladder " pilot burners, whereby all the main burners are ignited from one pilot burner, are acceptable if properly installed. Their disadvantages are that they liberate heat where it is not required, and that partial blockage of the run of the ladder will leave one or more burners unprotected. Two types of ladder pilot burner have been developed—the slot type, in which the pilot flame issues from a longitudinal slot in the burner tube, and the multiple-hole type in which it issues from closely spaced small holes. It is essential that the material from which burners are made should retain its strength at the operating temperature and should be corrosion resistant. The burner must be securely and correctly located relative to the main burners and must be protected from falling deposits, etc.; and, to ensure continuity of the ladder pilot flame, the sensing element of the flame-failure device must be located at the end of the ladder pilot and opposite to that at which the pilot will be lit.

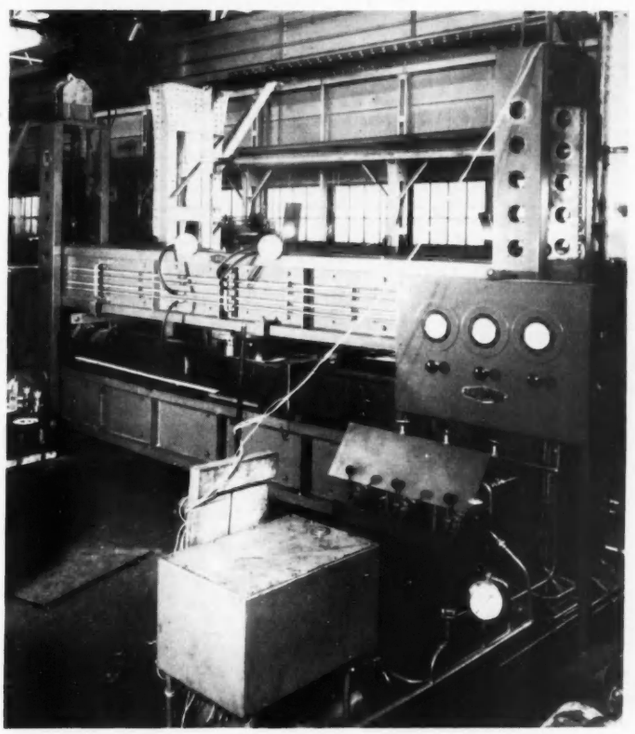
In selecting a flame-failure device, the major factors to be considered are the gas rate, enclosed volume, and the type of construction. Whether or not such a device is necessary depends mainly on the enclosed volume and whether secondary explosions caused by inflammable vapours or dusts are likely to form additional hazards. The decision having been taken, the type of device to be fitted depends on the gas rate, higher gas rates calling for a quicker response.

TESTING STRUCTURAL MEMBERS

VARIABLE LOAD-APPLICATION POINTS

Structural members such as beams, roof trusses and aircraft components can be tested under variable loading conditions in a machine installed in the civil engineering laboratory, University of Bristol. The design, which is based on a specification prepared by Professor Sir Alfred Pugsley, is due mainly to Fielding and Platt, Limited, Gloucester (who also built and erected the machine), working in close co-operation with Dr. E. F. Gibbs and Dr. A. H. Chilver, of the Department of Civil Engineering at the University.

The machine consists, basically, of a loading frame, the upper member of which is adjustable to accommodate specimens of various heights, three double-acting hydraulic cylinders which enable loads to be applied in any position within the plane of the frame, hydraulic pumping and control equipment, and means for measuring the loads. The arrangement of the testing machine gives a maximum test space 18 ft. 6 in. long and 6 ft. high. It is possible to carry out tests on beams up to about 20 ft. long by 5 ft. high, and to apply transverse load tests on spans up to about 16 ft. Provision is made for the attachment of extension pieces to the machine to enable specimens somewhat longer than the normal maximum to be tested. The total loading possible is 100 tons transverse, with simultaneous end loading up to 25 tons if required.



The loading of specimens at any point within the plane of the machine frame is possible on the structure-testing machine which has been built at Bristol University.

MOVABLE HYDRAULIC RAMS

The load-applying structure of the machine comprises two divided vertical columns at 17 ft. 6 in. centres, which carry a fixed lower beam and a movable upper beam. The upper beam can be adjusted by 8 in. vertical steps to give a clear gap of from 2 ft. to 6 ft. between the beams. Chain pulley blocks are built on to the tops of the vertical columns for raising and lowering the upper beam, which is locked in its working position by retaining pins passing through machined holes in the beam ends and in the columns.

The beams, like the columns, are divided, and two 50 ton hydraulic rams can be fixed in the spaces between the beam sides. These rams can be placed at any required point along the upper or lower beam, thus enabling the load to be applied in any chosen position on the specimen. An additional ram of 25 tons capacity is available, and this can be mounted on a swivel attached to either of the vertical columns, when it will give a thrust horizontally or at any angle to the horizontal up to a maximum of $\pm$ 45 deg. Alternatively, the 25 ton ram may be placed in the upper or lower beam.

INDIVIDUAL CONTROL OF RAMS

A single electrically-driven hydraulic pump, with a maximum output of 1·25 gallons per minute at 2 tons per sq. in., serves the three hydraulic rams through an arrangement of fixed and flexible piping with pressure take-off points in appropriate positions so that the rams can be placed as required. There is an independent set of controls for each of the three rams, each set consisting of a control valve, pressure controller, needle valve, check valve and stop valve. Only one other control point is provided on the complete machine; this is the handwheel which is used to regulate the output of the pump.

The control valve is directional, and enables the oil flow to be used for loading or for " drawback " of the ram. The calibrated pressure controller is used either to pre-set a maximum pressure and therefore load, or else to vary the pressure on the ram. The function of the check valve is to provide for an unrestricted exhaust flow from the loading ram when it is being withdrawn; this exhaust flow cannot take place through the pressure controller. The needle valve enables the pressure to be reduced at a rate between that obtained by using the pressure controller and the drawback.

The control system, which uses valves in normal commercial production, has proved in operation to be very successful. It enables a constant pressure to be maintained in each of the three loading rams, and no interaction between the rams has occurred, except when one of them has been unloaded instantaneously on the drawback. The flexibility of the specimen then induced a small increase of load on the rams still in operation, but these rams soon re-adjusted themselves to the pre-set pressure. The effect described can be eliminated by reasonably slow unloading of the ram which it is desired to take out of operation.

Loads are measured either directly by means of gauges, which show the pressure behind the rams, or indirectly by load cells in series with the rams.

HIGH-TEMPERATURE MATERIALS*

METALS AND ALLOYS FOR AIRCRAFT-ENGINE CONSTRUCTION

By H. E. Gresham

During the first quarter of the century it became clear that there was quite a considerable reduction of strength when a metal was raised to a temperature which was well removed from that of forging, or still more removed from its melting point (Fig. 1). The need for metallurgists to develop alloys with improved strength at elevated temperatures, was thus imperative. A further condition which was also slow to be recognised, was that there was a time factor involved in the resistance of a material to a set load as distinct from the known weakening of material due to the application of repeated loading above what is now termed the fatigue limit. Although we can now look back and see how obvious these conditions ought to have been it was not at all easy to see these facts clearly 30 years ago, and there were very few metallurgists or engineers who were properly aware of the effects of temperature on strength.

In the late twenties the problem began to be more clarified although there was still a great deal of haziness about the application of knowledge to practical problems and it became evident that work on creep, fatigue and oxidation resistance would have to be intensified and added to the work which was already in progress on ordinary temperature properties. Work was carried out on steels which are ferritic at room temperatures in order to develop higher strength materials for steam turbines, and also on austenitic materials particularly on behalf of aero engine design and development, although we must not forget the work done as well in this field for steam turbines.

Perhaps at this stage it should be explained that the term " creep " is a stress/strain/time function at any arbitrary fixed temperature (Fig. 2). The engineer or designer to-day, however, prefers it expressed with reference to some fixed time interval for a specific strain or rupture stress. Similarly, at elevated temperatures there is no true fatigue limit for any metallic material used to-day and this figure must also be stated at some agreed stress/number of reversals to failure (Fig. 3). In the development of better materials both these fundamental rupture forms must be known.

* Paper read before Section G of the British Association at Sheffield on Friday, August 31, 1956.

POPPET VALVE DEVELOPMENTS

It could probably be said with truth at the beginning of the second World War that the most highly developed metallurgical product was the aero-engine poppet valve. This valve was made of stable austenitic steel containing approximately 14 per cent. nickel, 14 per cent. chromium, with small quantities of tungsten and/or molybdenum, together with the other usual elements, carbon, silicon, and manganese. This valve was coated on the head and the seat face with a cobalt-base alloy or an alloy of nickel and chromium. It was sodium cooled, in that there was a hole along the stem just into the head which was two-thirds filled with metallic sodium, the heat being transferred from the head to the stem by the mechanical movement of the sodium; from the stem the heat was transferred into the guides and the cylinder head.

Another steel which had been developed for valves was one containing 22 per cent. chromium and 12 per cent. nickel with tungsten and other elements, although it was not so popular as the first mentioned steel. It could be said that these steels were developed very much by *ad hoc* methods, but as such they did represent a wealth of experience both in steel metallurgy and life at elevated temperatures under severe conditions.

PRECIPITATION HARDENING

Early in the century the aluminium-base alloy known as Duralumin had been discovered and with it the phenomenon of precipitation hardening. Essentially, this makes use of the change of solubility of an element in the parent metal by dissolving it at a high temperature P and precipitating it at a lower one, T (Fig. 4). This phenomenon was studied with avidity by metallurgists and was applied to steel in the 1930's resulting in the production of steels which were capable of being age-hardened after solution treatment. These steels contained deliberate additions for this purpose. It should be noted that austenitic stainless steels containing 18 per cent. chromium and 8 per cent. nickel had been developed particularly for corrosion resistance at atmospheric temperatures. During their development it had been found necessary to add carbide stabilisers such as titanium or niobium in order to prevent denudation of chromium in solution in the iron, at the crystal boundaries.

The point to emphasise is that with the exception of the complex steel containing copper, molybdenum and titanium, which was strongly age-hardening, the materials mentioned above were all in commercial production in this country prior to 1939, largely in and around the city of Sheffield. Thus we can say that for 30 years there had been a steady growth of development resulting in materials which can be obtained quite strong at elevated temperatures and this advance had been accomplished by the co-ordination of research work in the various metallurgical fields, for, after all, although aluminium is very much lighter than and has a melting point much below that of iron they both follow the same fundamental laws.

STEELS FOR TURBINE DISCS

The idea of the gas turbine as a power unit for aeroplanes had been mooted for some years before the second World War, but of the variations tried out, the Whittle concept was to prove the most successful. This engine depended, among other things, for its success in the initial stages, on the materials which had been developed for the steam-turbine and aero engine (see Table I). The turbine disc was made of Stayblade, an austenitic steel which was well known for steam-turbine blades. The turbine blades themselves were made of the strongly precipitation hardened steel called REX.78. The combustion chambers were made of nickel-chromium alloy; the jet pipe was made of austenitic stainless steel sheet and the compressor was made of aluminium alloy which had been developed for the pistons and superchargers of internal-combustion engines.

The advent of a practicable gas-turbine of reasonable weight marked the beginning of a new era for metallurgical development in high temperature materials. The problems to be solved were more definable and the metallurgist became more of a partner to the engineer, instead of having to make a new material and find its practical value without knowing what was required as a dominant feature.

When the early engines were run it was found that quite a number of parts were mechanically unreliable. However, these deficiencies were ironed out and a higher specific power was then demanded. This increase in power was obtained by raising the speed and the temperature. As a result turbine discs, which had been carefully designed to avoid bursting from the centre, broke at the rim, due to the high temperature the steel attained at the periphery. This failure of the disc material at the root fixing of the turbine blades had creep characteristics. It was estimated that the temperature of the disc rim was approaching that of the turbine blades due to the hot gas sweeping the periphery of the disc, and it is interesting to note that in those days the temperature distribution was first estimated by the oxide colours developed.

The turbine disc steel was replaced by another steel which had been developed originally for aero-engine valves, but not used in production. It was

TABLE I.—Percentage Composition of Various Alloys.

Alloy	Percentage of elements present											
	C	Mn	Si	Ni	Cr	Mo	V	Cu	Fe	Al	Ti	Mg
Stayblade ..	0·22	0·60	1·00	8·50	20·0	—	—	—	Bal.	—	1·20	—
Rex. 78 ..	0·06	0·82	0·65	17·5	14·4	3·60	0·27	4·25	Bal.	—	1·00	—
Inconel ..	0·15	0·75	0·40	Bal.	13·5	—	—	—	7·50	—	0·55	—
Staybrite ..	0·13	0·50	0·50	8·00	18·20	—	—	—	Bal.	—	0·55	—
Aluminium alloy, RR59	—	—	0·87	1·15	—	—	—	2·20	1·03	Bal.	0·13	1·55

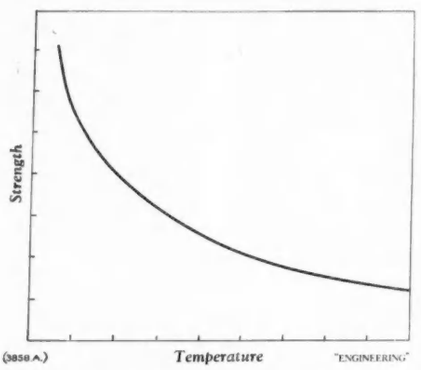


Fig. 1 Showing decrease in strength of metals with increasing temperature.

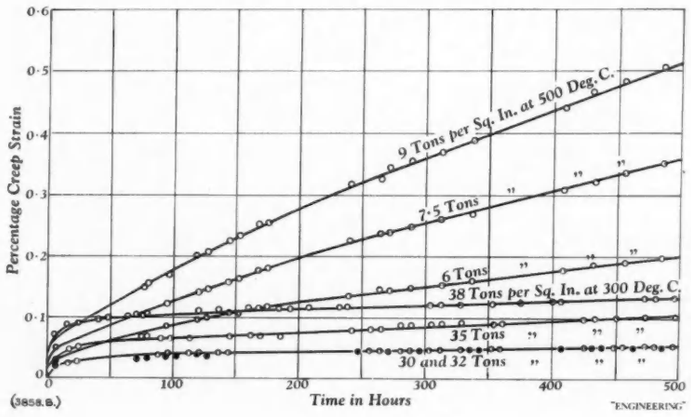


Fig. 2 (left) Creep strain of S62 material at different temperatures.

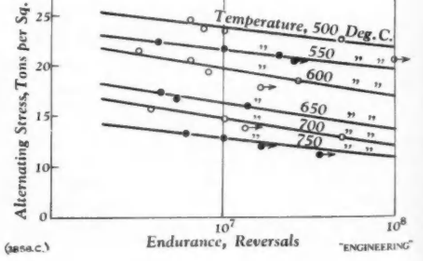


Fig. 3 (right) Fatigue tests on 14 Ni-14 Cr austenitic steel to S111 1¼ in. diameter rolled bar. Heat treatment: 1 hour at 950 deg. C., air cool.

a steel which, as well as the 14 per cent. nickel, 14 per cent. chromium mentioned as a valve steel, had additions of 10 per cent. cobalt, and 3 per cent. niobium (Fig. 5). It had a much higher creep strength at 700 deg. C., that is, it could stand a higher stress at 700 deg. C. for the same time, or alternatively, it could stand the same stress for a longer time. The use of this steel cured the disc rim creep failures at the increased engine rating and in fact enabled the engine to complete a 500 hour test. This was the first time such a test had been completed on an aero jet engine. A disadvantage of this steel, however, was its low yield stress so that considerable stretching of the disc was experienced during the first stages of the engine running and consequent trouble with disc seal clearances and danger of turbine blade tip rubbing.

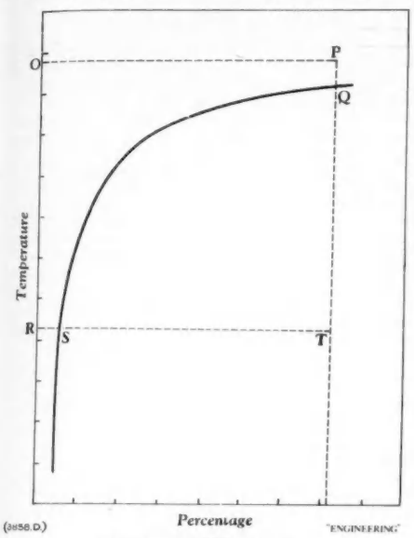


Fig. 4 Solubility curve.

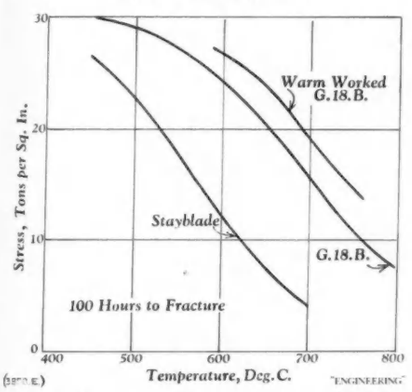


Fig. 5 Creep strength of early disc materials.

In order to improve the yield stress, applying experience from aluminium alloys, an age-hardening treatment at 800 to 850 deg. C. was arrived at, and this enabled an appreciable number of discs to be run with reduced stretch on the engine. A disadvantage of this ageing treatment was that a proportion of the creep strength of the steel was lost but it was a useful compromise for a critical period in the development of the jet engine. From the knowledge that with this type of steel cold work could be retained up to 700 deg. C., which temperature existed at the rim of the disc in the engine, came the idea of raising the yield stress by this means. It was found that the creep strength of the steel was not impaired by the presence of cold work. The cold working was actually carried out on the disc forgings, by pressing them at about 800 to 850 deg. C. and of course was dubbed "warm-working." A large number of discs in this steel, "warm-worked," were used successfully with the elimination of the stretch trouble in the engine, and incidentally, warm working was found to improve the creep strength.

The turbine disc material has developed along a second path. It was realised in the development of the aero gas-turbine that for bigger turbines a great saving in weight could be made by using a ferritic steel disc with its higher yield strength if the rim of the disc could be insulated from the hot gases. The design conception brought the operating conditions, and thus the material requirements, into the range which could be attained by the development of ferritic steels (Figs. 6 and 7). Certain steels known to have useful creep strengths up to 400 deg. C. immediately presented themselves for this application, such as the 3 per cent. chromium (DTD.306), and soon steels with appreciable creep strengths up to 450 deg. C. were evolved. These were the lower chromium steels (2 per cent.) with additions of molybdenum and vanadium, such as HGT.3 and H.40, but it was realised that these being non-stainless there would be difficulty in finding a protection against corrosion. Great efforts were therefore directed to the development of the creep strength of the 12 per cent. chromium steels. This was achieved by small additions of molybdenum, vanadium, niobium, etc., with a carbon content of about 0·2 per cent. This development resulted in steels such as REX.448, H.46 and HGT.4 which will give creep strengths of the order of 20 tons per sq. in. at 500 deg. C. for 0·1 per cent. creep strain in 100 hours. These steels are now widely used as disc materials in British aero engines and are giving very good service.

MATERIALS FOR GAS-TURBINE BLADES

Turning to the subject of gas-turbine blades, the requirements for these are: (1) good resistance to oxidation and corrosion by hot gases; (2) high creep strength; and (3) adequate endurance when subjected to high-frequency alternating stresses. It has already been stated that the first gas-turbine blades were in steel, but very soon it was apparent that the material would not have adequate creep resistance. The successor was a nickel-chromium base alloy. In this case, as with development of aluminium alloys, an age-hardening system was discovered resulting in an alloy which gave greatly enhanced creep, tensile and fatigue strength at high temperatures with the already well known very good scale resistance of the 80/20 nickel-chromium base alloy. The additions which gave rise to the precipitation hardening effect were titanium and aluminium in small amounts. This alloy was called Nimonic 80, the first of a series of remarkably creep-resistant alloys which enable turbine blades to be run at temperatures of the order of 750 deg. C. with stresses up to 14 tons per sq. in.

With the advent of this alloy of course there were troubles in manufacture, forging, processing, etc., which had to be overcome. One of the most difficult was to produce a material which was clean, free from oxide, stringers of complex titanium compound, and non-metallic inclusions. Great strides have been made in this direction over a period of time so that to-day the Nimonics are much superior in quality to the early Nimonic 80 in which it was not unusual to have stringers of inclusions three-quarters the length of the blade. Another trouble experienced in the early days for blades was the intergranular cracking of the surface on running, with consequent premature failure. This cracking was found to be due to work hardening of the blade surface during machining and was cured by a very short-time anneal at a high temperature in a specially developed flux bath to protect the surface.

With the experience gained in the manufacture and handling of Nimonic 80 over a period of time, the alloying elements titanium and aluminium were increased and the iron content decreased with a consequent gain in the creep strength of the material; the alloy became known as Nimonic 80A (Figs. 8 and 9). This enabled higher temperatures to be used in the engine resulting in increased thrust and hence higher speeds were attained by the aircraft. This alloy has been very successful in use and the blades of the Dart engines, which power the Viscount aircraft, are of this material. With the improvements in materials and design, engine temperatures were again being pushed up to obtain more and more power from as small and light an engine as possible and considerable effort was maintained in developing better blade materials. With Nimonic 80 most of the creep strength was obtained by the precipitation hardening effect of the titanium and aluminium additions to the nickel-chromium base. Nimonic 90 was developed from Nimonic 80 by the addition of about 20 per cent. cobalt to stiffen up the nickel-chromium base at high temperatures, so here we have a good example of a high-temperature alloy in which the creep strength has been developed by two means—precipitation hardening and a stiffening up by alloying of the base material. Nimonic 90 was used for the blades of the engines of the aircraft which raised the World Air-Speed record to over 600 m.p.h. The constant demand for higher temperatures resulted in a further development of the Nimonic series in the form of Nimonic 95, the improved creep properties of which were obtained by a further increase of the precipitation hardening elements titanium and aluminium. With this, a higher solution heat-treatment temperature was necessary to realise the benefit of the increased amounts. Together with the development of these alloys it must be realised that the metallurgical and forging technique was constantly being improved, the object being to produce consistent good quality

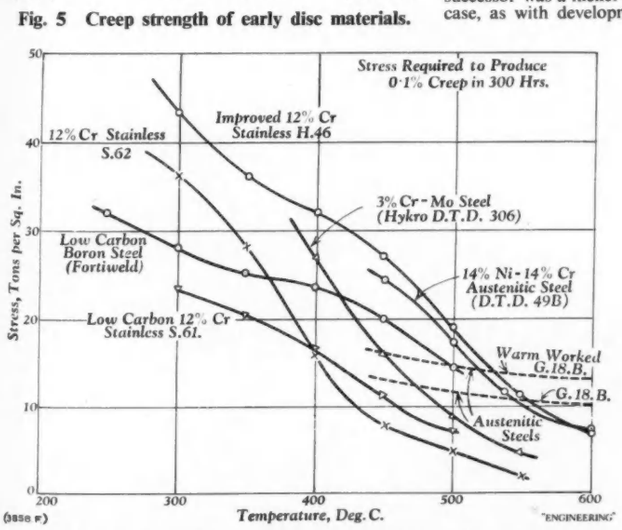

Stress Required to Produce 0·1% Creep in 300 Hrs.
Improved 12% Cr Stainless H.46
12% Cr Stainless S.62
3% Cr-Mo Steel (Hykro D.T.D. 306)
Low Carbon Boron Steel (Fortiweld)
14% Ni-14% Cr Austenitic Steel (D.T.D. 49B)
Low Carbon 12% Cr Stainless S.61.
Warm Worked G.18.B.
G.18.B.
Austenitic Steels
Stress, Tons per Sq. In.
Temperature, Deg.C.
(3858.F)
"ENGINEERING"

Fig. 6 Creep strength of ferritic and austenitic steels at different temperatures.

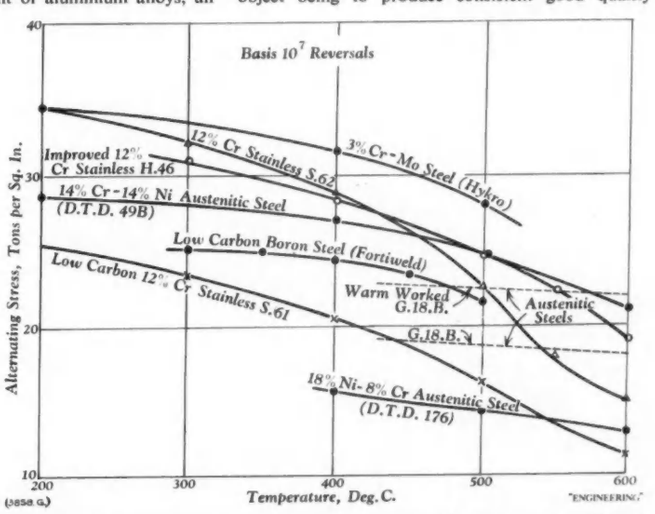


Fig. 7 Fatigue strength of ferritic and austenitic steels at different temperatures.

forgings. Nimonic 95 has been in service for several years in engines and is subjected to temperatures in the order of 900 deg. C. It was used in the engine of the aircraft which recently attained a recorded speed of over 1,100 m.p.h.

MATERIALS FOR NOZZLE GUIDE VANES

In order that the turbine blades may extract energy from the system, the hot gases from the burners are deflected on to them at a known angle by the stationary or stator blades, commonly called nozzle guide vanes. These blades or vanes tell a similar story of development, the material ranging from a simple nickel-chromium alloy followed by a cobalt-chromium-molybdenum alloy, then an austenitic steel and now back to complex nickel-base alloys. They are usually made by the wax investment casting method, although fabricated vanes have been used. Initially the alloy used for these castings was a cobalt base one known as Vitallium—a dental alloy, which had excellent casting properties.

The properties required of the alloys used for this application are firstly oxidation resistance, secondly reasonable creep strength at temperatures higher than those of the turbine blades, and thirdly resistance to repeated heating and cooling. This last effect may lead to distortion and/or cracking. The mechanism of this failure process is not fully understood but it will be appreciated that the forces involved must be extremely high when it is possible to crack an edge of a high-strength material after a few cycles. The ductility under static-load conditions is no direct criterion of its cyclic properties. If the material is very ductile the part will be badly deformed which, in the case of a nozzle guide vane, causes loss of efficiency and possible overheating of the turbine blades. Conversely, if the material has low ductility but high strength it may crack with little or no deformation and still function efficiently, though its life will of course be lessened.

RESEARCH AND EXPERIMENT

Different alloys, however, do not conform to any known law and the problem is to find the best for service. This is done by trial; firstly, on standard shaped specimens in a test rig which sorts out the poorer, and then on actual parts on a rig, Fig. 10, and finally on the engine. The rig shown consists of an engine flame tube with controls. The hot gases from the combustion are passed on to test prices or guide vanes and blades. Any set cycle of heating and cooling can be applied and as the parts do not heat up or cool down uniformly the materials are subjected to thermal cyclic stressing which will eventually fail them if the imposed conditions are severe. The ideal solution of this important problem would be an alloy with zero coefficient of expansion for the full range of temperature, or perfectly uniform heating and cooling of the entire part where a flame is used on an aerofoil or irregular shape. The former is unknown and the latter becomes impossible.

It will be appreciated therefore that research workers have had to carry out a great number of tests on a large number of experimental alloys and this work has resulted in a gradual improvement in materials for vanes. This has led to a manifold increase in the life of this part, and also that of engine overhaul period, which for the Dart in the Viscount has increased from 400 hours to 1,050 hours. Similar changes have taken place in the sheet alloys used for flame tubes, starting with Inconel, a nickel-base alloy containing 14 per cent. chromium, 6 per cent. iron, followed by the nickel-chromium alloy Nimonic 75. While these alloy changes have shown some overall improvement, the effect of design has probably been of greater influence on the life of this part.

LIGHT ALLOYS FOR HIGH TEMPERATURES

Although one is apt to think of " high temperature" with relation to temperatures above red heat, it should be realised this is only relative in our normal perception of the temperature scale. The development of highly efficient radial and particularly axial compressor design has been made more practical by the use of light alloys at temperatures which must be considered as high or " elevated " in relation to their older previous load-temperature conditions and their melting points.

These recently found alloy compositions made it possible to cast complicated design shapes in large numbers where fabrication by brazing or welding steel parts together would have been very costly and time consuming, apart from problems of distortion, even with designs of simpler unit construction. These aluminium alloys now known as RR.250 and RR.350 —which contain copper, nickel, cobalt, manganese, with or without antimony and zirconium in balanced proportions—in the cast and heat-treated condition give a life of at least 100 hours at 4·3 and 5·5 tons per square inch respectively at 300 deg. C. with a tensile strength of about 10 tons per square inch, while the 350 alloy has actually been used at a temperature of 375 deg. C. quite satisfactorily in service. These figures represent an improvement in permissible operation temperatures of 100 deg. C. over previously known sand casting alloys. An unusual material, pure aluminium plus alumina, extruded and forged, has remarkable properties at temperatures as high as 400 to 450 deg. C. and has been used for compressor blades, while some magnesium alloys containing zirconium and rare-earths combine lightness and good properties up to 300 deg. C.

UNITED STATES DEVELOPMENTS

The search for better alloys in the United States has been mainly confined to blade materials and while this country was developing the forged type they have in the main concentrated their researches on casting and cast alloys for rotating blades. An improved type of cobalt-base alloy containing 25 per cent. chromium, 11 per cent. nickel and 7·5 per cent. tungsten, and a number of variants of this with molybdenum up to 6 per cent. and niobium up to 6 per cent. have been developed and used.

Some nickel-base wrought alloys have been produced but these are in the main only slight variations of English alloy compositions. Their chief improvement has been the melting and casting of these alloys in a high vacuum which has given appreciable increases in the time to fracture. This technique is now well established with furnaces holding up to a ton or more and outputs of over 1,000 tons a year.

FUTURE POSSIBILITIES

Many of the alloys now in high temperature usage have reached or are approaching the limit of stress and temperature beyond which it will be necessary to approach the problem from a new angle or with a new base metal. With only certain available materials at their disposal the Germans adopted air-cooling whereas we were able to avoid this design complication. We are probably approaching a similar situation although at a higher temperature. The local temperatures attained for short periods on the guide vanes are often less than 100 deg. C. below that at which melting begins and the turbine gas temperature on a standard engine is above 900 deg. C. The higher melting point base metals are tungsten, molybdenum, chromium, tantalum, vanadium, zirconium and titanium and of the non-metallic materials, carbon, carbides, cermets and ceramics. The bulk availability must be considered as well as other physical properties in making a decision. At present none of the suggested materials possesses all the required properties but, for instance, if a non-brittle impermeable refractory stable coating could be realised many of the metals, or their alloys, would have great possibilities and would give an impetus to development.

It is hoped this paper has indicated the successful result of the challenge to the metallurgist over the last fifteen years. It will be very interesting to follow the outcome during the next fifteen years.

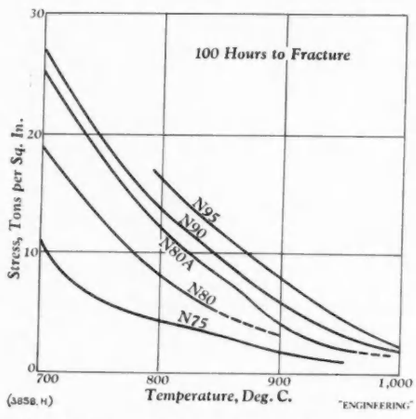


Fig. 8 Creep strength of nickel-base alloys.

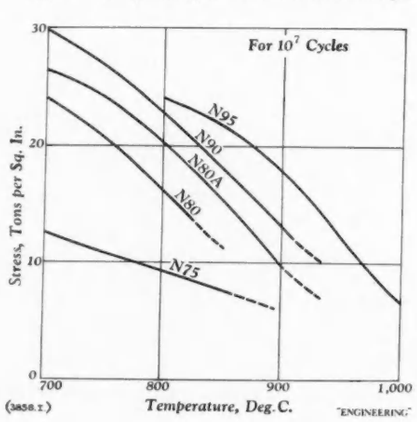


Fig. 9 (left) Fatigue strength of nickel-base alloys.

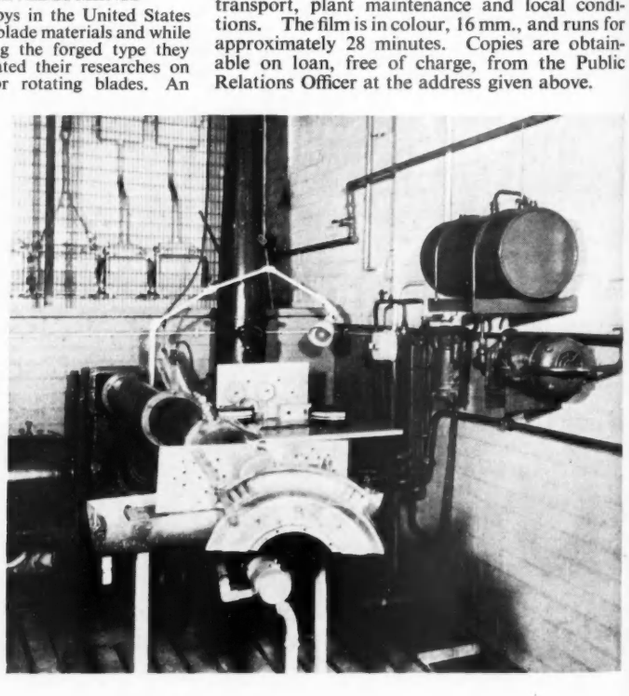


Fig. 10 (right) Testing equipment for aero gas-turbine blades and nozzle guide vanes.

★ ★ ★

"CHANCE FOR A LIFETIME"

A film which shows clearly some of the adventurous items connected with civil engineering construction, has been prepared by John Laing and Son, Limited, 4 Regent-street, London, S.W.1, for showing to school leavers as a guide to their choice of career. It is entitled " Chance for a Lifetime."

The film demonstrates construction in its widest sense, ranging from oil refineries to cement works, power stations and dams in this country and abroad, with all their difficulties of transport, plant maintenance and local conditions. The film is in colour, 16 mm., and runs for approximately 28 minutes. Copies are obtainable on loan, free of charge, from the Public Relations Officer at the address given above.

Book Reviews

THOSE IN CHARGE OF THOSE WHO DO

Selection and Training of Foremen in Europe. By SVEN GRABE and PAUL SILBERER. Project No. 234. *Organisation for European Economic Co-operation, 2 Rue André-Pascal, Paris 16, France.* (650 francs); and *H.M. Stationery Office, Kingsway, London, W.C.2.* (12*s.* 6*d.*)

A story was told during the war of a young woman in a factory who went angrily to her foreman on a Friday, to complain that her wages had been made up short. The foreman looked at the wage packet and said: "It's all right girlie, they've given you mine."

Attention began to be paid to the pay and status of foremen when our lives depended on production, at the same time that the old sanction of unemployment had disappeared. But it was not only the problems of industrial discipline which the foreman, often himself newly promoted, faced in war-time; there were new products to be turned out in large quantities by new methods; there was the rigour of Services inspection; there were the shortages of raw materials and difficulties of planning; there was the need to train new workers and de-skill old jobs. The answer to many of these problems was further development of specialist staff departments, with the result that the foremen found large sections of his authority removed and his status in doubt.

The very word foreman itself, as this study by two experts of the International Labour Office points out, covers a variety of functions and scopes of responsibility; and the difficulties of the war and post-war periods have disclosed the inadequacy of the methods employed by most firms for defining the foreman's job and for his selection and recruitment. This study demonstrates that these problems are common to industry in all countries, although the degree to which steps have been taken to deal with them naturally varies a good deal; but there is little new which progressive managements will learn from it, except what is being done in a number of other countries.

The authors conclude that a new concept of the foreman is developing in which he is regarded as the representative of the management with specific functions; but that there has been a certain over-estimation of the possibilities of training and education exclusively on the foreman level. These are only part of the larger policies of organisation, human relations and personnel development. In particular, functions must be clearly defined and communicated to the foreman; his superiors must use the same principles of leadership in dealing with him as he is taught to use with those in his charge; and his status must be such as to attract the best candidates.

In a sense this report is already in danger of becoming out of date. It has nothing to say of the problem of the foreman in industries becoming increasingly scientific, or where the automatic control of processes has greatly reduced the numbers of men to be supervised but increased the complexity and area of the plant. What is the relation between the functions of the foremen in charge of a road gang, of a steel mill, and of a chemical plant? May there not have been an exaggeration of the part that the foreman, as a channel of managerial discipline, is going to play in the factories of the future?

ECONOMICS OF POWER

Power Production. By HANS THIRRING. *George G. Harrap and Company, Limited, 182 High Holborn, London, W.C.1.* (25*s.*)

This book is described as a comprehensive survey for students and economists, technicians, industrial planners and the general reader. That is a fairly wide market but it will be noted that it does not specifically include engineers or scientists. Perhaps the ideal book for the intelligent sixth-former whom one wants to attract to an engineering career, and required reading for economists and all students intending to enter the civil service or the administrative side of industry, it would have been a better book for the non-specialist reader if some of the excellent general descriptive chapters had not received an infusion of formulae.

Encyclopaedic in coverage, the chapters deal with every aspect of the sources and uses of power and the engines used in its production. The chapters on the sources of energy deal not only with the normal fuels and water power and their availability, but also with fuels derived from vegetation, with solar energy and, in three detailed chapters, with atomic energy.

Underlying all the descriptions of energy converting processes and methods of power production, there is emphasis on their economics and on the reserves of energy sources on which they are based. They are therefore very relevant to our present situation in this country and, for this reason alone, the book should be widely read by those who have to make decisions involving fuel consumption. For instance, the British Transport Commission and the Central Electricity Authority and their sponsoring Government departments might note the comment that the maximum of fuel economy on British Railways is likely to be achieved by electrification of all main lines, and by suitable choice of sites for power stations so that their reject heat can be used for household and industrial purposes.

There is an interesting section on the costs of power transmission which compares the costs of electricity distribution with the cost of transport of different fuels; including a very topical comparison of costs of transporting fuel-oil by pipeline and by tanker.

In view of the importance of bringing home to responsible people the alternative costs of different sources of power and the economics of alternative methods of its utilisation, it is a pity that the excellent descriptive material in this book was not presented in a tidier form and without the introduction of theoretical concepts and formulae which may put off the general reader.

* * *

NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

Rubber in Automobile Engineering. By R. DEAN-AVERNS. *The Natural Rubber Development Board, Market Buildings, Mark-lane, London, E.C.3.* (5*s.*)

The aim of this book is to familiarise automobile designers with the characteristics and possibilities of rubber. Engine vibration problems and suspension systems are considered in detail; other uses of rubber dealt with include the pneumatic tyre; the clutch, drive, steering and brakes; rubber in units attached to the body or frame; electric fittings, hoses, and seals; rubber in body building and mounting; and rubber in door mounting, glazing, panels, flooring and seating.

Molecular Flow of Gases. By G. N. PATTERSON. *John Wiley and Sons, Incorporated, 440 Fourth-avenue New York 16, N.Y., U.S.A.* (7.50 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (60*s.*)

In this book intended for engineers and physicists concerned with supersonic aerodynamics, the characteristics of a gas flow are determined from an assumed molecular model and the distribution of the velocities of the molecules. It covers isentropic flows, non-isentropic flows and the mechanics of rarefied gases. The mathematical standard of the treatment does not differ greatly from that normally required in the continuous theory of fluid mechanics. The mathematical development is complete only for a monatomic gas, but the results can be applied to a diatomic gas if the appropriate adjustments are made in the values of the ratio of specific heats and the Prandtl number.

Process Control Analysis. By MILLARD H. LAJOY and E. ALLEN BAILLIF. *Instruments Publishing Company, Incorporated, 845 Ridge-avenue, Pittsburgh 12, Pennsylvania, U.S.A.* (2 dols.)

The treatment is based on the simple representation of the closed-loop system in terms of elementary resistance and capacitance elements which give rise to ordinary linear differential equations of fairly low order. These equations are then solved analytically. After discussing the use of an analogue computer, the book concludes with a discussion on the stability of the closed-loop control system.

Über die Tragfähigkeit von Gleitlagern unde ihre Berechnung. By PROF. DR.-ING. G. VOGELPOHL. Forschungsberichte des Wirtschafts- und Verkehrsministeriums Nordrhein-Westfalen, No. 268. *Westdeutscher Verlags/Köln und Opladen, Germany.* (16.85 D.M.)

This pamphlet is an account of an investigation into the loading of friction bearings and the calculation of the necessary data for that purpose. It is pointed out that while friction bearings were formerly almost exclusively used in machine construction, they have now, to an increasing extent, been replaced by roller bearings the design of which is carried out on a scientific basis and about which a great deal of fundamental data is available. On the other hand, friction bearings were designed almost entirely on empirical lines with results which were not always satisfactory. An account is given of the experimental work which has been done to correct this position and some examples are given of how this has been applied in practice.

* * *

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Mobile Free-Piston Air Compressor. MACKAY INDUSTRIAL EQUIPMENT LTD., Faggs-road, Feltham, Middlesex. Free piston engine in which work done by opposed Diesel pistons is directly converted into energy in the form of compressed air. Capacity 132 cub. ft. per min. of free air at 90 lb. per sq. in. Illustrated descriptive leaflet with technical data.

Sealing Rings. PIONEER OILSEALING AND MOULDING CO. LTD., Cottontree Works, Colne, Lancashire. Pioneer Nu-lip synthetic-rubber sealing rings, of basically square section with annular grooves, claimed to eliminate spiral twist and reduce frictional resistance when used as reciprocating seals in place of O-rings. Descriptive leaflet and specification.

Electric Pump. ARTHUR LYON & CO. (ENGINEERS) LTD., 6 Carlos-place, Grosvenor-square, London, W.1. Alcon ¾ in./1 in. electrically-driven self-priming pump, to suction lift of 25 ft., operating on water ring principle. Non-self-priming version also available. Maximum output 450 gallons per hour. Specification leaflet.

Centrifugal Pump. SIGMUND PUMPS LTD., Team Valley, Gateshead 11. PumPak electric single-shaft pumping set, for air conditioning, circulating systems, water supply, etc., in capacities from 20 to 500 Imperial gallons per minute. Illustrated specification leaflet.

Compression Joints for Pipe-lines. CHARLES RYAN & CO. LTD., 2-20 Capper-street, London, W.C.1. Straight couplings, T-couplings, elbows, diminishers, cross couplings, etc., for butane gas installations and water, air, petrol, oil lines up to medium pressures. Price list.

Motor Controller. S. BROD & CO., LTD. 31/33 Priory Park-road, London, N.W.6. Electronic controllers for ¼, ½, 1 and 2 h.p. motors. Speed maintenance within ± 1 per cent. of setting over mains fluctuation from − 10 to + 5 per cent. and from 47 to 65 cycles. Leaflet.

Chains and Couplings. RENOLD CHAINS LTD., Renold House, Wythenshawe, Manchester. Chains and chain drives for use in all industries. Also spider, disk and chain couplings. Brochure illustrated in colour throughout showing many applications.

Belting. REVOL LTD., Exchange Buildings, Quayside, Newcastle-upon-Tyne 1. Leather, woven, Balata, and friction belting, V-ropes. Manufacture, treatment, maintenance. Reference booklet.

STATICALLY INDETERMINATE FRAMES

THE TWO BASIC APPROACHES TO ANALYSIS

*By T. M. Charlton**

The analysis of statically-indeterminate structures requires the use of the conditions for the compatibility of strains as well as those for the equilibrium of the joints. If these two sets of conditions are formally satisfied, two courses are available for the completion of the anaylsis and these can be described as the equilibrium method and the compatibility method respectively. Examples of the former approach are those of total potential energy and general strain energy methods for equilibrium and the slope-deflection method used for rigid-jointed frames, while the latter approach is often used in the form of the complementary energy method (Castigliano's so-called Principle of Least Work when Hooke's law is obeyed). Insufficient attention seems to be given to the relative merits of the two approaches, and the purpose of this article is to recall their salient features.

The above remarks are perhaps best clarified by means of an example. Suppose that it is desired to analyse the hypothetical pin-jointed plane frame, with three redundant members, shown in Fig. 1. It will be assumed that:—

(*a*) the members are in tension,

(*b*) the extensions e of the members are small, such that the horizontal and vertical displacements h_p and v_p of the "free" joint P are negligible in comparison with the horizontal and vertical projected lengths of the members, and

(*c*) the cartesian coordinates of the joints are $x_1, y_1; x_2, y_2; \ldots\ldots x_p, y_p$ respectively.

Now the conditions for equilibrium are:—

$$\left.\begin{aligned} &H_p + T_1\frac{x_1-x_p}{l_1} + T_2\frac{x_2-x_p}{l_2} + \ldots\ldots \\ &\qquad + T_5\frac{x_5-x_p}{l_5} = 0 \quad . \quad (a) \\ &V_p + T_1\frac{y_1-y_p}{l_1} + T_2\frac{y_2-y_p}{l_2} + \ldots\ldots \\ &\qquad + T_5\frac{y_5-y_p}{l_5} = 0 \quad . \quad (b) \end{aligned}\right\} (1)$$

where l denotes the length and T the force in the member indicated.

The conditions for compatibility of strains are:—

$$e_1 = (h_1 - h_p)\frac{x_1-x_p}{l_1} + (v_1 - v_p)\frac{y_1-y_p}{l_1}$$

and, since $h_1 = v_1 = 0$,

$$\left.\begin{aligned} e_1 &= -h_p\frac{x_1-x_p}{l_1} - v_p\frac{y_1-y_p}{l_1} \quad . \quad (a) \\ \text{Similarly,}\quad & \\ e_2 &= -h_p\frac{x_2-x_p}{l_2} - v_p\frac{y_2-y_p}{l_2} \quad . \quad (b) \\ e_3 &= -h_p\frac{x_3-x_p}{l_3} - v_p\frac{y_3-y_p}{l_3} \quad . \quad (c) \\ e_4 &= -h_p\frac{x_4-x_p}{l_4} - v_p\frac{y_4-y_p}{l_4} \quad . \quad (d) \\ e_5 &= -h_p\frac{x_5-x_p}{l_5} - v_p\frac{y_5-y_p}{l_5} \quad . \quad (f) \end{aligned}\right\} (2)$$

The equilibrium method consists of expressing the e's in terms of the T's by means of the load-extension characteristics (thus, for linear members $e = \frac{Tl}{AE}$, where A is the cross-sectional area and E is Young's modulus) and substituting for the T's in terms of h_p and v_p, found by equations (2), in the equilibrium equations (1). Two final simultaneous equations of equilibrium in the variables h_p and v_p would thus be obtained, from which these quantities could be found, and hence the e's and T's could be computed.

On the other hand, the compatibility method consists of eliminating h_p and v_p from equations (2), so obtaining three equations in the five e's which can then be converted into equations in T's by making use of the load-extension characteristics of the members, e.g., $e = \frac{Tl}{AE}$, as above. There would thus be three final equations of compatibility in three variables T, if two of the five variables T were eliminated by means of the equilibrium equations (1).

There is no doubt that for this particular example, the former (equilibrium) approach would be the more convenient, no matter how many redundancies were involved, and the advantage of this approach for highly redundant frames has been noted by D. Williams.* In general then, the first step in choosing the best approach consists of inspecting the frame to see whether the number of components of joint displacements is greater or less than the number of redundancies. Thus, the hypothetical frame shown in Fig. 2 has two redundancies while there are nine components of joint displacements, and, in this case, it is reasonable to expect, therefore, that the compatibility method would be the more convenient. Again, the frame shown in Fig. 3 has five redundancies but only four components of joint displacements, so that the equilibrium method would appear to be preferable. In making the choice, however, aspects of symmetry and superposition (for linear systems), should be considered, because such factors might invalidate the generalisations which are otherwise implied.

At this point it is convenient to investigate the operation of the other energy approaches whereby strain-energy is used for setting up the equations of equilibrium (equilibrium method) or whereby complementary energy is used for setting-up the equations of compatibility (compatibility method). The former depends upon the equality of strain energy and external work done for a small variation of external forces. Thus for the example of Fig. 1:—

$$H_p\,\delta h_p + V_p\,\delta v_p = \sum_{i=1}^{i=5} T_i\,\delta e_i \quad . \quad (3)$$

This method is quite general and is not confined to linear systems, but for the sake of illustration it will be supposed that all of the members of the frame have linear load-strain characteristics and are of the same material (and therefore have a common Young's modulus E). Thus $T = e\frac{AE}{l}$ and equation (3) can be re-written:—

$$H_p\,\delta h_p + V_p\,\delta v_p = E\sum_{i=1}^{i=5}\frac{A_i}{l_i}e_i\,\delta e_i. \quad (4)$$

Remembering the compatibility relationships (2) above, it follows that

$$H_p\,\delta h_p + V_p\,\delta v_p = E\sum_{i=1}^{i=5}\frac{A_i}{l_i}\left(h_p\frac{x_i-x_p}{l_i} + v_p\frac{y_i-y_p}{l_i}\right)\times\left(\delta h_p\frac{x_i-x_p}{l_i} + \delta v_p\frac{y_i-y_p}{l_i}\right). \quad (5)$$

Since δh_p and δv_p are independent, then

$$\left.\begin{aligned} H_p &= E\sum_{i=1}^{i=5}\frac{A_i}{l_i}\left(h_p\frac{x_i-x_p}{l_i} + v_p\frac{y_i-y_p}{l_i}\right)\left(\frac{x_i-x_p}{l_i}\right) \\ V_p &= E\sum_{i=1}^{i=5}\frac{A_i}{l_i}\left(h_p\frac{x_i-x_p}{l_i} + v_p\frac{y_i-y_p}{l_i}\right)\left(\frac{y_i-y_p}{l_i}\right) \end{aligned}\right\} (6)$$

which are the two equilibrium equations (1) expressed in terms of h_p and v_p. The lumped coefficients of h_p and v_p in these two equations represent the stiffness coefficients of the system.

By variation of the complementary energy,* however:—

$$h_p\,\delta H_p + v_p\,\delta V_p = \sum_{i=1}^{i=5} e_i\,\delta T_i = \frac{1}{E}\sum_{i=1}^{i=5}\frac{l_i}{A_i}T_i\,\delta T_i \quad . \quad . \quad . \quad (6)$$

and, by making use of the equilibrium equations (1), each member force, T_i, can be expressed in terms of any three member forces, say T_1, T_2 and T_3, and H_p and V_p. Similarly, the small change in each member force δT_i can be expressed in terms of δT_1, δT_2, δT_3, δH_p and δV_p by the equations of equilibrium because the method is concerned with systems of forces in equilibrium and compatible displacements (assuming that the geometry of the loaded structure is substanti-

* Of the Department of Engineering, University of Cambridge.

* D. Williams, "Relations between the Energy Theorems applicable in Structural Theory," *Phil. Mag.*, vol. 60, page 617 (1938).

* T. M. Charlton, "Analysis of Statically Indeterminate Structures by the Complementary Energy Method," ENGINEERING, vol. 174, page 389 (1952).

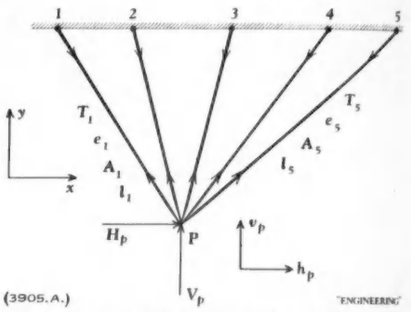


Fig. 1 A hypothetical pin-jointed plane frame. This type of frame, with only two components of joint displacement to consider—no matter what number of redundancies are involved—is best solved by equilibrium methods.

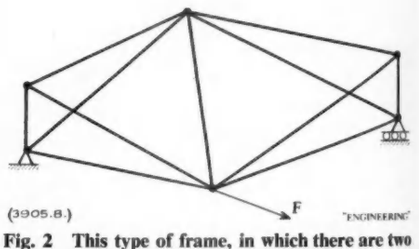


Fig. 2 This type of frame, in which there are two redundancies but nine components of joint displacement, is most conveniently tackled by compatibility methods.

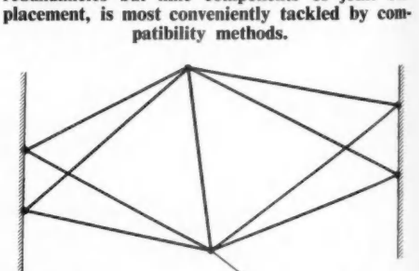


Fig. 3 This frame, like that in Fig. 1, has more redundancies (five) than components of joint displacements (four), and is most easily resolved by the use of equilibrium methods.

ally the same as that of the unloaded structure). Thus, by equations (1), if $\alpha_0, \alpha_1, \ldots, \alpha_3$ and $\beta_0, \beta_1, \ldots, \beta_3$ are geometrical constants:—

$$\left.\begin{aligned} T_4 &= H_p + \alpha_0 V_p + \alpha_1 T_1 + \alpha_2 T_2 + \alpha_3 T_3 \\ \delta T_4 &= \delta H_p + \alpha_0 \delta V_p + \alpha_1 \delta T_1 + \alpha_2 \delta T_2 + \alpha_3 \delta T_3 \\ T_5 &= H_p + \beta_0 V_p + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3 \\ \delta T_5 &= \delta H_p + \beta_0 \delta V_p + \beta_1 \delta T_1 + \beta_2 \delta T_2 + \beta_3 \delta T_3 \end{aligned}\right\} \quad (7)$$

whence

$$\begin{aligned} h_p \delta H_p + v_p \delta V_p = \frac{1}{E}\Big[& \frac{I_1}{A_1} T_1 \delta T_1 + \frac{I_2}{A_2} T_2 \delta T_2 \\ & + \frac{I_3}{A_3} T_3 \delta T_3 + \frac{I_4}{A_4} (H_p + \alpha_0 V_p + \alpha_1 T_1 \\ & + \alpha_2 T_2 + \alpha_3 T_3)(\delta H_p + \alpha_0 \delta V_p + \alpha_1 \delta T_1 \\ & + \alpha_2 \delta T_2 + \alpha_3 \delta T_3) + \frac{I_5}{A_5} (H_p + \beta_0 V_p \\ & + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3)(\delta H_p + \beta_0 \delta V_p \\ & + \beta_1 \delta T_1 + \beta_2 \delta T_2 + \beta_3 \delta T_3)\Big]. \quad . \quad (8) \end{aligned}$$

or since δH_p, δV_p, δT_1, δT_2 and δT_3 are independent :—

$$\begin{aligned} h_p &= \frac{I_4}{E A_4} (H_p + \alpha_0 V_p + \alpha_1 T_1 + \alpha_2 T_2 + \alpha_3 T_3) \\ &\quad + \frac{I_5}{E A_5} (H_p + \beta_0 V_p + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3) \\ v_p &= \alpha_0 \frac{I_4}{E A_4} (H_p + \alpha_0 V_p + \alpha_1 T_1 + \alpha_2 T_2 + \alpha_3 T_3) \\ &\quad + \beta_0 \frac{I_5}{E A_5} (H_p + \beta_0 V_p + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3) \\ 0 &= \frac{I_1}{E A_1} T_1 + \alpha_1 \frac{I_4}{E A_4} (H_p + \alpha_0 V_p + \alpha_1 T_1 + \alpha_2 T_2 \\ &\quad + \alpha_3 T_3) + \beta_1 \frac{I_5}{E A_5} (H_p + \beta_0 V_p + \beta_1 T_1 + \beta_2 T_2 \\ &\quad + \beta_3 T_3) \\ 0 &= \frac{I_2}{E A_2} T_2 + \alpha_2 \frac{I_4}{E A_4} (H_p + \alpha_0 V_p + \alpha_1 T_1 \\ &\quad + \alpha_2 T_2 + \alpha_3 T_3) + \beta_2 \frac{I_5}{E A_5} (H_p + \beta_0 V_p + \beta_1 T_1 \\ &\quad + \beta_2 T_2 + \beta_3 T_3) \\ 0 &= \frac{I_3}{E A_3} T_3 + \alpha_3 \frac{I_4}{E A_4} (H_p + \alpha_0 V_p + \alpha_1 T_1 \\ &\quad + \alpha_2 T_2 + \alpha_3 T_3) + \beta_3 \frac{I_5}{E A_5} (H_p + \beta_0 V_p \\ &\quad + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3). \quad . \quad . \quad (9) \end{aligned}$$

The five compatibility equations (9) are sufficient to enable the five unknowns, T_1, T_2, T_3, h_p and v_p to be found. In fact, if the member forces only are required the last three compatibility equations are sufficient and are identical with the three final equations which would have been obtained by the formal compatibility method described above. In these equations the lumped coefficients of the respective forces represent the appropriate flexibility coefficients.

The alternative energy approaches are, then, merely means of setting-up the alternative final equations and the choice of method depends upon the nature of the structure. The methods are all perfectly general; that is to say, they are not restricted to linear elastic structures, but while the strain energy (equilibrium) method can be adapted to take account of gross distortion of the structure under load, such adaptation of the complementary energy method is not possible.

In the case of rigid-jointed frames for which axial deformation of members is negligible, a counterpart of the so-called equilibrium method is the slope-deflection method, while the corresponding compatibility method is the inversion of the slope-deflection method. Thus, by the former method, the individual members are considered, as shown in Fig. 4, and the moments applied to the ends are expressed in terms of the angular displacements ϕ_A, ϕ_B and ψ as follows:—

$$\left.\begin{aligned} M_A &= \frac{2EI}{l}(2\phi_A + \phi_B - 3\psi) \\ M_B &= \frac{2EI}{l}(\phi_A + 2\phi_B - 3\psi) \end{aligned}\right\} \quad (10)$$

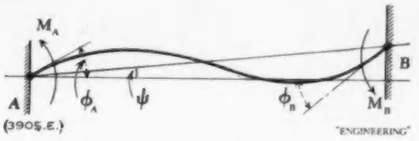


Fig. 4 The slope-deflection method—essentially an equilibrium method—requires consideration of each member individually.

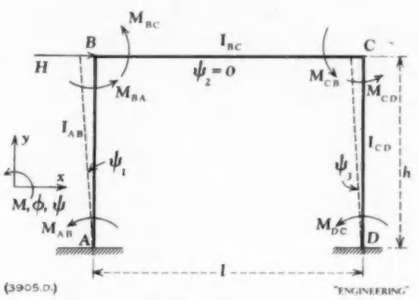


Fig. 5 A rectangular frame with fixed feet is conveniently resolved by taking advantage of the slope-deflection method.

For the frame with encastred feet, shown in Fig. 5, the procedure would be as follows:—

Member A B

$$\left.\begin{aligned} M_{AB} &= \frac{2EI_{AB}}{h}(2\phi_{AB} + \phi_{BA} - 3\psi_1) \\ M_{BA} &= \frac{2EI_{AB}}{h}(\phi_{AB} + 2\phi_{BA} - 3\psi_1) \end{aligned}\right\} \quad (11)$$

Member B C

$$\left.\begin{aligned} M_{BC} &= \frac{2EI_{BC}}{l}(2\phi_{BC} + \phi_{CB} - 3\psi_2) \\ M_{CB} &= \frac{2EI_{BC}}{l}(\phi_{BC} + 2\phi_{CB} - 3\psi_2) \end{aligned}\right\} \quad (12)$$

Member C D

$$\left.\begin{aligned} M_{CD} &= \frac{2EI_{CD}}{h}(2\phi_{CD} + \phi_{DC} - 3\psi_3) \\ M_{DC} &= \frac{2EI_{CD}}{h}(\phi_{CD} + 2\phi_{DC} - 3\psi_3) \end{aligned}\right\} \quad (13)$$

The compatibility conditions are, however, given by:—

$$\left.\begin{aligned} &\phi_{AB} = 0; \quad \phi_{BA} = \phi_{BC} = \phi_B; \\ &\phi_{CB} = \phi_{CD} = \phi_C; \quad \phi_{DC} = 0; \\ &\psi_1 = \psi_3 = \psi; \quad \text{and } \psi_2 = 0. \end{aligned}\right\} \quad (14)$$

The equations of equilibrium are:—

$$\left.\begin{aligned} M_{BA} + M_{BC} &= 0 \\ M_{CB} + M_{CD} &= 0 \\ M_{AB} + M_{BA} + M_{CD} & \\ + M_{DC} - Hh &= 0 \end{aligned}\right\} \quad (15)$$

Thus by taking account of the compatibility conditions (14) in equations (11), (12) and (13) and substituting them, respectively, for the moments in equations (15), three equations of equilibrium in terms of three unknown displacements ϕ_A, ϕ_B and ψ are obtained and can be solved.

The inversion of the slope-deflection method (the compatibility method) consists of writing for each member, considered as shown in Fig. 4, and where l is the length of the member, the following equations:—

$$\left.\begin{aligned} \phi_A &= \frac{l}{6EI}(2M_A - M_B) + \psi \\ \phi_B &= \frac{l}{6EI}(-M_A + 2M_B) + \psi \end{aligned}\right\} \quad (16)$$

Applying these forms to the example of Fig. 5, the following expressions for the slopes at the ends of each of the members are obtained as follows:—

Member A B

$$\left.\begin{aligned} \phi_{AB} &= \frac{h}{6EI_{AB}}(2M_{AB} - M_{BA}) + \psi_1 \\ \phi_{BA} &= \frac{h}{6EI_{AB}}(-M_{AB} + 2M_{BA}) + \psi_1 \end{aligned}\right\} \quad (17)$$

Member B C

$$\left.\begin{aligned} \phi_{BC} &= \frac{l}{6EI_{BC}}(2M_{BC} - M_{CB}) + \psi_2 \\ \phi_{CB} &= \frac{l}{6EI_{BC}}(-M_{BC} + 2M_{CB}) + \psi_2 \end{aligned}\right\} \quad (18)$$

Member C D

$$\left.\begin{aligned} \phi_{CD} &= \frac{h}{6EI_{CD}}(2M_{CD} - M_{DC}) + \psi_3 \\ \phi_{DC} &= \frac{h}{6EI_{CD}}(-M_{CD} + 2M_{DC}) + \psi_3 \end{aligned}\right\} \quad (19)$$

The compatibility and equilibrium conditions are as before—equations (14) and (15)—and the next step is to apply the compatibility equations (14) and write:—

$$\begin{aligned} \phi_{AB} = 0 &= \frac{h}{6EI_{AB}}(2M_{AB} - M_{BA}) + \psi \\ \phi_{BA} = \phi_{BC} = \phi_B &= \frac{h}{6EI_{AB}}(-M_{AB} \\ &\quad + 2M_{BA}) + \psi = \frac{l}{6EI_{BC}}(2M_{BC} - M_{CB}) \\ \phi_{CB} = \phi_{CD} = \phi_C &= \frac{l}{6EI_{BC}}(-M_{BC} + 2M_{CB}) \\ &= \frac{h}{6EI_{CD}}(2M_{CD} - M_{DC}) + \psi \\ \phi_{DC} = 0 &= \frac{h}{6EI_{DC}}(-M_{CD} + 2M_{DC}) + \psi \\ & \quad . \quad . \quad . \quad (20) \end{aligned}$$

There now are six unknown moments and one unknown displacement to be found, i.e., seven unknowns in all, but by making use of the three conditions of equilibrium (15) the above four equations of compatibility can be expressed in terms of three unknown moments and ψ, when their solution is possible.

For the example considered, the latter method is clearly more cumbersome than the former, although, if stresses are the ultimate objective, the bending moments are obtained directly by the latter. On the other hand, if the feet of the frame had been pin-jointed, the equilibrium method would have led to five final equations in five unknowns while the compatibility method would have led to two final equations in two unknowns. (The two additional unknowns, ϕ_A and ϕ_D, would be introduced into the equilibrium method while the two unknowns M_{AB} and M_{DC} would be eliminated from the compatibility method). The choice of approach is again dependent, therefore, upon the particular circumstances. The alternative energy approaches are, of course, possible for rigid-jointed frames, but it is not proposed to elaborate upon this aspect here.

CONCLUSION

It is not intended to suggest that the formal applications of the two approaches, as set out above, are advantageous for dealing with the relevant practical problems. Appreciation of the duality aspect is, however, clearly important when deciding on the method of attacking a particular problem. Concerning the general problem of the value of so-called elastic analysis: it is worth remembering that, although it is of little value for finding stresses because of the various imperfections which are present in practice, it often provides a reliable estimation of the deflections produced by a specified system of loads.

CORE-BOX TURN-OVER MACHINE

OPERATION FREE FROM JOLTS

A machine designed specially by the Hymatic Engineering Company, Limited, Redditch, Worcestershire, to speed production in the Wednesbury factory of F. H. Lloyd and Company, Limited, has been installed recently. It is a turn-over unit for inverting, gently and without jolting, a core box containing rammed sand on to a core plate, ready for stripping. The box may weigh as much as a ton and a controlled turn-over is essential to avoid cracking the core. Up till now the task has been done by means of an overhead sling and a number of men taking the weight. Besides using valuable manpower, this method was slow and involved the risk of injury to the men and the possibility of shaking the box and damaging the core.

The turn-over device produced by the Hymatic Company is operated by one man, and the operation takes only from 30 to 60 seconds according to the conditions prevailing. The main components are two L-shaped rocker arms with cradles situated on a low-level roller conveyor. As may be seen in Fig. 1, the operator rolls a core box on to the right-hand rocker cradle and a core plate on to the left-hand rocker cradle. The left-hand rocker is then turned up in an inward direction, bringing the core-plate to an almost vertical position, as shown in Fig. 2. A retractable steadying bar, notched to accommodate varying thicknesses of plate, prevents the plate from sliding. The next operation is seen in Fig. 3, namely, the right-hand rocker is turned up in an inward direction and the box is brought through 90 deg. until it faces the core-plate. The inner arms of the two rockers are interlaced and a narrow row of rollers in the right-hand rocker allows the operator to move a shallow core box across to the plate before the next operation. This is seen in Fig. 4 and consists in turning the left-hand rocker down in an outward direction and placing the core box, now on its plate, on to the left-hand roller conveyor. Finally, the right-hand rocker is turned back to its original position ready to receive the next core box approaching from the right.

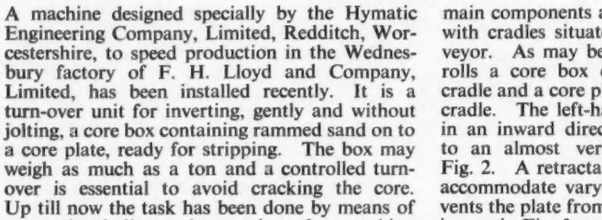


Fig. 1 Core box containing rammed sand, seen on right-hand rocker, and core plate on left-hand rocker. Behind is the control pedestal.

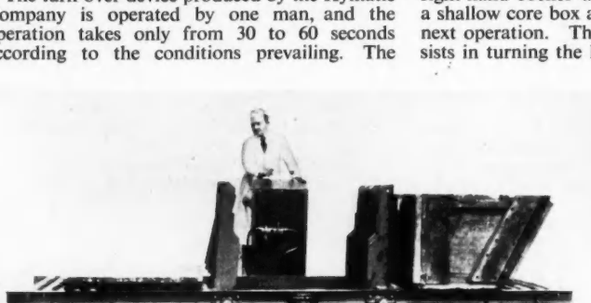


Fig. 2 First operation. The left-hand rocker is turned up inwardly, bringing the core plate to a vertical position.

Each rocker is operated by an air cylinder arranged horizontally within the frame and coupled to a similar oil-filled cylinder which acts as a speed controller The cylinder spindles, glands and bearing sleeves are protected from damage by foundry sand by suitable coverings. The oil-filled cylinders ensure the controlled movement of the rockers and, as a further precaution, cam-operated pilot valves exhaust the air cylinders just before the rockers come on to their stops.

The turn-over machine, which is capable of dealing with core boxes measuring up to 5 ft. wide and 3 ft. deep (with the core plate), is controlled by two hand levers mounted on the pedestal shown in the illustrations. The levers have a central "off" position which can be spring-returned.

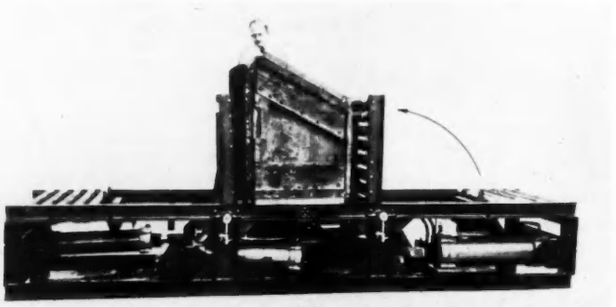


Fig. 3 Second operation. The core box is turned up through 90 deg., so that it faces the core plate.

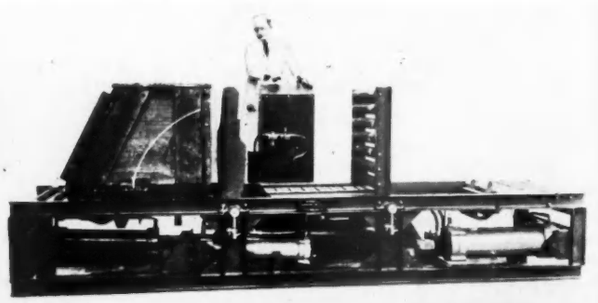


Fig. 4 Final operation. The core box is inverted gently and without jolting on to the core plate now on the outgoing roller conveyor.

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RADAR AT SEA

Decca's contribution to safety at sea is steadily increasing. A fortnight ago the total orders for Decca Marine Radar installations reached 6,000. The rate at which radar is being fitted to further vessels can be gauged from the fact that in February, 1955, the chairman of Decca Radar Limited announced that the company's marine radar had been fitted to 3,700 ships operated by 870 owners. By April of this year the number of installations ordered from Decca reached a total of 5,000.

A further significant announcement from this company is the fact that the new True Motion Radar TM.46, which was first introduced to ship owners on October 24, has already been ordered for fitting to more than 100 vessels. (See ENGINEERING, November 9, page 597.) This radar represents an important advance on previously available sets. All earlier installations presented the navigator's own ship as a spot in the centre of the radar screen and all other objects such as moving ships, stationary buoys or vessels and the coast line were portrayed relative to it. That method of picture presentation left the navigator with two problems: those of distinguishing moving from fixed bodies and of calculating the range and speed of moving vessels by continual observation of range and bearing. Decca's new system presents all fixed objects as fixed on the radar screen while the navigator's ship and all other moving objects travel across the face of the screen at true speed and course. This method of presentation should greatly reduce the labour and judgement required of the navigator.

Radar is being installed in ships of all sizes. The Decca True Motion radar has been ordered for vessels varying from passenger liners to cargo liners and tramps, while Marconi have had in full production for more than a year their "Quo Vadis" radar suitable for installation in ships with limitations of space and electrical power. At the same time improvements in technique are always welcome. Radar enables vessels to steam in poor visibility at speeds which would have seemed fantastic before its introduction. That it can lead to over-confidence and major disasters is appreciated by small boat navigators who now feel that their only safe refuge in fog lies in shoal waters into which large vessels cannot penetrate, and has been underlined by the Andrea Doria disaster. It remains true, of course, that the value of any equipment is dependent on the skill of the operator.

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A second course on acoustics for those with no preliminary knowledge of the subject is being arranged from April 1 to 6, 1957, at Southampton University. Particulars may be obtained from Mr. D. M. A. Mercer, Physics Department, The University, Southampton.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list, arranged chronologically, appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of exhibitions and conferences not included below may have appeared in ENGINEERING, *October* 26, *page* 543; *or November* 30, *page* 702. *Organisers are invited to send to the Editor particulars of coming events as soon as arrangements are made.*

National Boat Show, Third.—Tues., Jan. 1, to Sat., Jan. 12, in the Empire Hall, Olympia, London, W.14. Organised by the Ship and Boat Builders' National Federation, 205 Regent-street, London, W.1. Tel. REGent 1108.

Problems of Aircraft Production, Conference.—Tues. and Wed., Jan. 8 and 9, at the University of Southampton, Highfield, Southampton. Theme: "New Materials and New Methods." Organised by the Southern Section of the Institution of Production Engineers. Apply to the secretary of the Institution, 10 Chesterfield-street, London, W.1. Tel. GROsvenor 5254.

Motor Show, 39th International.—Sat., Jan. 12, to Wed., Jan. 23, in Brussels. Apply to the commissaire général, Salon de l'Automobile, 22 Rue du Luxemburg, Brussels.

Packaging Exhibition.—Tues., Jan. 22, to Fri., Feb. 1, at Olympia, London, W.14. Held in collaboration with the Institute of Packaging, and organised, in association with F. W. Bridges and Sons, Ltd., by Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester, 3. Tel. Deansgate 6363.

Western Springs Trade Exhibition.—Sat., Jan. 26, to Sat., Feb. 9, at Auckland, New Zealand. Apply to Auckland Provincial Public Relations Office, Achilles House, 45 Customs-street East, Auckland C.1, New Zealand.

***Canada Farm and Industrial Equipment Trade Show.**—Wed., Jan. 30, to Sat., Feb. 2, in the Coliseum Buildings, Toronto. Organised by the Canada Farm and Industrial Equipment Trade Show (Limited), 40 Wellesley-street East, Toronto, Canada.

Stationery Trade Fair.—Mon., Feb. 4, to Fri., Feb. 8, at the Grand and Metropole Hotels, Brighton. Organised by the Stationers' Association of Great Britain and Northern Ireland, 6 Wimpole-street, London, W.1. Tel. LANgham 9256.

***Education and Training of Naval Architects and Marine Engineers, Symposium.**—Wed., Feb. 6, at 10 Upper Belgrave-street, London, S.W.1. Organised jointly by the Institute of Marine Engineers, 85 The Minories, London, E.C.3 (Tel. ROYal 8493); and the Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. Tel. SLOane 4622.

Hi Fi Electrical and Radio Show.—Wed., Feb. 6, to Sat., Feb. 9, in Los Angeles, California. Organised by the Institute of Hi-Fi Manufacturers, 28 Broad-street, New York 4, U.S.A.

Commercial Vehicle Exhibition, 37th International.—Thurs., Feb. 7, to Sat., Feb. 16, at Amsterdam. Offices: R.A.I. Building, Amsterdam Z.1, Holland.

***Agricultural Exhibit, Fifth National.**—Fri., Feb. 8, to Sun., Feb. 17, in the Show Mart, Montreal. Organised by the Salon Nationale de l'Agriculture, 152 Notre Dame East, Montreal, Canada.

National Stationery and Book Trades Fair.—Mon., Feb. 11, to Fri., Feb. 15, at the Royal Horticultural Society's Old Hall, Vincent-square, and New Hall, Greycoat-street, London, S.W.1. Organised by the National Newsagent (Exhibitions), Ltd., 149 Fleet-street, London, E.C.4. Tel. CITy 2604.

Scottish Dairy Show.—Tues., Feb. 12, to Fri., Feb. 15, at Kelvin Hall, Glasgow. Organised jointly by the Corporation of Glasgow and the Scottish Agricultural Society. Apply to Mr. Walter Barlow, Kelvin Hall, Glasgow. Tel. Kelvin 1185.

National Nylon Fair.—Mon., Feb. 18, to Fri., Feb. 22, at the Royal Albert Hall, Kensington Gore, London, S.W.7. Apply to Mr. V. G. Sherren, National Trade Press Ltd., Drury House, Russell-street, Drury-lane, London, W.C.2. Tel. TEMple Bar 3422.

***Electricity and Productivity Conference and Exhibition.**—Mon., Feb. 18, to Fri., Feb. 22, at the Royal Dublin Society's Show Grounds, Ballsbridge, Dublin. Organised by the Electricity Supply Board, 27 Lower Fitzwilliam-street, Dublin, Eire.

Mechanical Engineers' Contribution to Clean Air, Conference on.—Tues., Feb. 19, to Thurs., Feb. 21, in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476. See ENGINEERING, October 26, 1956, page 519.

Boat Show, International.—Fri., Feb. 22, to Wed., Feb. 27, in Miami. Offices: 615 S.W. 2nd-avenue, Miami, Florida, U.S.A.

Hardware Trades Fair, Third—Mon., Feb. 25, to Fri., Mar. 1, at the Royal Horticultural Society's Old and New Halls, Vincent-square and Greycoat-street, London, S.W.1. Organised by Universal Exhibitions, Ltd. 74 Holland-park, London, W.11. Tel. PARk 7723.

Food, Cookery and Catering Trades Exhibition.—Tues., Feb. 26, to Sat., Mar. 9, at the City Hall, Deansgate, Manchester. Including food-processing machinery. Organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester, 3. Tel. Deansgate 6363.

Degreasing, All-Day Discussion.—Wed., Feb. 27, at The University, Edgbaston, Birmingham. Organised by the Institute of Metals, 17 Belgrave-square, London, S.W.1. Tel. BELgravia 3291.

Motor Cycle Exhibition.—Thurs., Feb. 28, to Sun., Mar. 10, at Amsterdam. Offices: R.A.I. Building, Amsterdam Z.1, Holland.

Metals under High Rates of Strain, Conference on.—In March, probably in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476.

Smallwares Trade Fair.—Mon., Mar. 4, to Fri., Mar. 8, at the Metropole Hotel, Brighton. Organised by Trade and Technical Exhibitions Ltd., 1 Dorset Buildings, Salisbury-square, London, E.C.4. Tel. FLEet Street 1555.

Copenhagen International Fair.—*Technical Fair:* Tues., Mar. 5, to Wed., Mar. 13. *Commercial Fair:* Sat., Mar. 23, to Sun., Mar. 31. In Copenhagen, Denmark. Organised by the International Messe, Vester Farimagsgade 6, Copenhagen V, Denmark. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

Ideal Home Exhibition.—Tues., Mar. 5, to Sat., Mar. 30, at Olympia, London, W.14. Organised by Associated Newspapers Ltd., 161-163 Queen Victoria-street, London, E.C.4. Tel. FLEet Street 6000.

***Western Kenya Agricultural Show.**—Fri. and Sat., Mar. 8 and 9, at Endoret, Kenya. Organised by the Royal Agricultural Society of Kenya, The Show Ground, P.O. Box No. 500, Nakura, Kenya.

Atomic Exposition and Nuclear Congress, International.—Mon., Mar. 11, to Fri., Mar. 15, at the Convention Hall, Philadelphia. Apply to Mr. H. F. Grebe, International Atomic Exposition, 117 South 17th-street, Philadelphia 3, Pa., U.S.A.

Motor Show, International.—Thurs., Mar. 14, to Sun., Mar. 24, in Geneva. Apply to the secrétariat général, Motor Show, 1 Place du Lac, Geneva, Switzerland.

Kansas City, International Trade Fair.—Sun., Mar. 17, to Sun., Mar. 24, at Kansas City. Apply to Mr. L. L. Bratschie, Heart of America International Trade Fair, Inc., 3230 Broadway, Kansas City 11, Missouri, U.S.A.

Photographic Exposition, International.—Fri., Mar. 22, to Sun., Mar. 31, at the National Guard Armory, Washington. Apply to Mr. R. J. Wilkinson, International Photographic Exposition, 104 East Michigan-avenue, Jackson, Michigan, U.S.A.

Physical Society's Exhibition of Scientific Instruments and Apparatus.—Mon., Mar. 25, to Thurs., Mar. 28, in the Royal Horticultural Society's Old and New Halls, Vincent-square and Greycoat-street, London, S.W.1. Organised by the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

Western Metal Congress and Exhibition.—Mon., Mar. 25, to Fri., Mar. 29, in the Pan Pacific Auditorium, Los Angeles, California. Organised by the American Society for Metals, 7301 Euclid-avenue, Cleveland 3, Ohio, U.S.A.

Industrial Textiles Fair, Second National—Mon., April 1, to Fri., April 5, at the Royal Albert Hall, Kensington Gore, London, S.W.7. Apply to Mr. V. G. Sherren, National Trade Press Ltd., Drury House, Russell-street, Drury-lane, London, W.C.2. Tel. TEMple Bar 3422.

***Electrical Industries Show, Fourth National.**—Mon., April 8, to Thurs., April 11, at the 71st Regiment Armory, New York. Organised by the American Electrical Industries Exposition, Inc., 19 West 44th-street, New York, 36, U.S.A.

Radio Component Show, 14th.—Tues., April 9, to Thurs., April 11, at Grosvenor House, Park-lane, London, W.1. Pre-view for overseas and special guests on Mon., April 8. Annual private exhibition organised by the Radio and Electronic Component Manufacturers' Federation, 21 Tothill-street, London, S.W.1. Tel. ABBey 4226. Applications for admission must be made in advance.

Chemical Engineering Education Symposium.—Tues, April 9, to Thurs., April 11, at The University, Birmingham. Organised by the Midlands Branch, Institution of Chemial Engineers. Apply to the secretary of the Institution, 16 Belgrave-square, London, S.W.1. Tel. BELgravia 3647.

Electrical Engineers' Exhibition, Sixth.—Tues., April 9, to Sat., April 13, at Earl's Court, London, S.W.5. Sponsored by the Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. Apply to Mr. P. A. Thorogood, Electrical Engineers (A.S.E.E.) Exhibition, Ltd., 6 Museum House, 25 Museum-street, London, W.C.1. Tel. MUSeum 3450.

British Photo Fair.—Thurs., April 11, to Wed., April 17, at Olympia, London, W.14. Apply to British Organisers Ltd., 52 Grafton-way, London, W.1. Tel. EUSton 7930.

London Audio Fair.—Fri., April 12, to Mon., April 15, at the Waldorf Hotel, Aldwych, London, W.C.2. Organised, on behalf of Audio Fairs Ltd., by C. Rex-Hassan and Associates, 42 Manchester-street, London, W.1. Tel. WELbeck 9111.

United States World Trade Fair.—Sun., April 14, to Sat., April 27, at the New York Coliseum, New York. *Managers:* The Charles Snitow Organisation, Inc., 331 Madison-avenue, New York, 17. Information may be obtained from the British Commonwealth Chamber of Commerce in the United States, 677 Fifth-avenue, New York, 22; and from the Fair's British and Commonwealth Office, Dudley House, 36 and 38 Southampton-street, London, W.C.2. Tel. TEMple Bar 8947.

Materials Handling Exposition, National.—Mon., April 29, to Fri., May 3, in the Convention Hall, Philadelphia. Apply to Clapp and Poliak Inc., 341 Madison-avenue, New York 17.

Factory Equipment Exhibition, Fifth.—Mon., April 29, to Sat., May 4, at Earl's Court, London, S.W.5. Theme: "Greater Efficiency in Industry." Organised by Factory Equipment Exhibitions, Ltd., 4 Snow-hill, Holborn-viaduct, London, E.C.1. Tel. CENtral 0354.

Health Congress.—Tues., April 30, to Fri., May 3, at Folkestone. Organised by the Royal Society of Health, 90 Buckingham Palace-road, London, S.W.1. Tel. SLOane 5134.

***Office Equipment Exhibition.**—In May, at Tokyo. Organised by the Japan Office Management Association, 2/1 Ginzanishi, Chuo-ku, Tokyo.

Caribbean Exhibition.—Fri., May 3, to Sun., May 19, at Port of Spain, Trinidad. Apply to the Junior Chamber of Commerce of Trinidad, Port of Spain, Trinidad.

***Home Building Exposition, Second International.**—Sat., May 4, to Sun., May 12, in the Coliseum, New York. Exposition offices: 250 West 57th-street, New York 19, U.S.A.

Japan International Trade Fair.—Sun., May 5, to Sun., May 19, at Harumi Pier Grounds, Harumicho, Chuo-ku, Japan. Apply to Fair Management Office, Tokyo International Trade Fair Commission, c/o Economic Bureau, Tokyo Metropolitan Government, Marunouchi 3-Chome, Chiyoda-ku, Tokyo, Japan.

Industrial Tool and Production Show of Canada.—Mon., May 6, to Fri., May 10, in the Industry Building, Exhibition Park, Toronto. Apply to Mr. E. M. Wilcox, 19 Melinda-street, Toronto, Canada. (Alteration of dates).

Engineered Castings Show, First; and the 61st A.F.S. Castings Congress.—Mon., May 6, to Fri., May 10, at Cincinnati Music Hall, Cincinnati, Ohio, U.S.A. Sponsored by the American Foundrymen's Society, Golf and Wolf-roads, Des Plaines, Illionis, U.S.A.

British Industries Fair.—Mon., May 6, to Fri., May 17, in the B.I.F. Buildings, Castle Bromwich, Birmingham. Organised and controlled by the Birmingham Chamber of Commerce. Apply to the organisers: P.O. Box 6, 95 New-street, Birmingham 2. Tel. Midland 5021.

Spring Show and Industries Fair.—Tues., May 7, to Sat., May 11, in Dublin. Organised by the Royal Dublin Society, Ballsbridge, Dublin.

Instruments, Electronics and Automation Exhibition, First.—Tues., May 7, to Fri., May 17, at Olympia, London, W.14. Promoted by the British Electrical and Allied Manumfacturers' Association and four other trade associations. Organised by Industrial Exhibitions, Ltd., 105-106 New Bond-street, London, W.1. Tel. HYDe Park 9583.

***Midwest Automotive Trade Show.**—Thurs., May 9, to Sun., May 12, in the Kiel Auditorium, St. Louis. Organised by the Midwest Automotive Trade Show, Inc., 2841 Locust-street, St. Louis 3, Missouri, U.S.A.

***Tractor Show, International.**—Sun., May 12, to Sun., May 19, in the Exhibition Building, Valentino Park, Turin, Italy. Organised by the Saloni Internazionale della Technica. Apply to the Agricultural Engineers Association, 6 Buckingham-gate, London, S.W.1. Tel. TATe Gallery 7973.

***Office Machinery Exposition.**—Mon., May 13, to Thurs., May 16 at Los Angeles, California. Organised by the National Office Management Association, 132 West Chelten-avenue, Philadelphia 44, Penn., U.S.A.

***Protective Clothing and Safety Equipment Exhibition, First.**—Mon., May 13, to Fri., May 17, at Olympia, London, W.14. Organised by the U.T.P. Exhibitions Ltd. (Associate company of United Trade Press Ltd.), 9 Gough-square, Fleet-street London, E.C.4. Tel. FLEet Street 3172.

Packaging Exhibition.—Tues., May 14, to Tues., May 21, in the R.A.I. Building, Amsterdam. Organised by N.V. 't Raedthuys, 5 Tesselschadestraat, Amsterdam, Holland.

***German Handicrafts and Trade Fair, International.**—Wed., May 15, to Sun., May 26, at Munich. Organised by Verein für Handwerks-Ausstellungen und Messen e. V., Theresienhöhe 14, Munich 12, Germany.

***Scottish Radio and Television Exhibition.**—Wed., May 22, to Sat., June 1, at the Kelvin Hall, Glasgow. Organised by the Radio Industry Council, 59 Russell-square, W.C.1. Tel. MUSeum 6901.

Book Exhibition, Second International.—Sun., May 26, to Thurs., May 30, at Sherman Hotel, Chicago. *Agent:* Mr. A. P. Wales, Dudley House, 36–38 Southampton-street, London, W.C.2. Tel. TEMple Bar 8947.

Waikato Agricultural Winter Show.—Tues., May 28, to Tues., June 4, in Hamilton, New Zealand. Apply to Mr. W. H. Paul, Box 616, Hamilton, New Zealand.

Bath and West Agricultural Show.—Wed., May 29, to Sat., June 1, at Swindon. Organised by the Bath and West and Southern Counties Society, 3 Pierrepont-street, Bath. Tel. Bath 3010.

Electronics in Automation, Convention.—In June, at King's College, Cambridge. Organised by the British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. Tel. MUSeum 1901.

Internal-Combustion Engine Congress, Fourth International.—Mid-June, at Zürich. Apply to Mr. C. C. M. Logan, secretary, British National Committee, 6 Grafton-street, London, W.1. Tel. HYDe Park 5107. See ENGINEERING, December 2, 1955, page 753.

Printing Industries and Allied Trades, International Exhibition.—Sat., June 1, to Sun, June 16, in Lausanne. Offices: 6 Avenue Mon-Repos, Lausanne, Switzerland.

World Power Conference Sectional Meeting.—Wed., June 5, to Tues., June 11. Trade Unions' Building, Belgrade, Yugoslavia. Apply to the British National Committee, 201 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 3966. (Extension of closing date.)

Three Counties Agricultural Show.—Tues., June 11, to Thurs., June 13, at Hartpury, Gloucester. Organised by the Three Counties Agricultural Society, Berrington House, 2 St. Nicholas-street, Hereford. Tel. Hereford 3969.

***Safety and Factory Efficiency Exhibition.**—Fri., June 14, to Fri., June 21, at Bingley Hall, Birmingham. Organised by Birmingham and District Industrial Safety Group, Industrial Safety Training Centre, 22 Summer-road, Acocks Green, Birmingham 27.

***Atomic Energy Exhibition, International.**—Sun., June 16, to Sat., Aug. 31, at Schiphol Airport, near Amsterdam, Holland. Organised with the support of the Dutch Government, the Amsterdam City Council, and the Amsterdam Chamber of Commerce. Secretariat offices: 37 Roemer Visscherstraat, Amsterdam. *Agents:* Galitzine and Partners Ltd., 17 Victoria-street, London, S.W.1. Tel. ABBey 4013.

***Electrical Power Convention Exhibition.**—Mon., June 17, to Fri., June 21, at Devonshire Park, Eastbourne. Organised by the British Electrical Development Association, 2 Savoy-hill, London, W.C.2. Tel. TEMple Bar 9434.

Business Efficiency Exhibition.—Mon., June 17, to Thurs., June 27, at Olympia, London, W.14. Organised by the Office Appliances and Business Equipment Trades Association, 11-13 Dowgate-hill, Cannon-street, London, E.C.4. Tel. CENtral 7771.

British Commonwealth Welding Conference.—Mon., June 17, to Sat., June 29, in London and Saltburn-by-Sea. Organised by the Institute of Welding, 29 Park-crescent, London, W.1. Tel. LANgham 7485.

Commercial and Scientific Exhibition.—Mon., June 24, to Wed., June 26, at the Show Mart, Montreal. Held in conjunction with the 23rd Congress of the Catholic Hospitals of the Province of Quebec. Apply to the Comité des Hôpitaux de Quebec, 325 Chemin Sainte-Catherine, Outremont, Montreal 8, Canada.

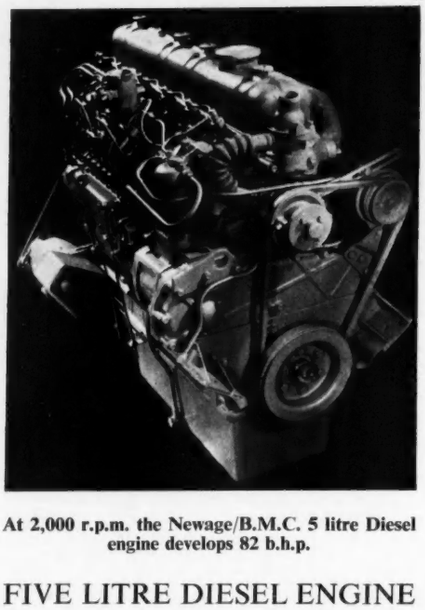
Exchange of Management Information, 11th International Conference.—Mon., June 24, to Fri., June 28, in Paris. Apply to the British Institute of Management, 8 Hill-street, London, W.1. Tel. GROsvenor 6000.

***Housewares Show, Second International.**—Mon., June 24, to Fri., June 28, in the Coliseum, New York. Organised by the Housewares Shows Corporation, 19 West 44th-street, New York 36, U.S.A.

***Bond and Crack Formation in Reinforced Concrete, RILEM Symposium.**—Thurs., June 27, to Sun., June 30, in Stockholm. Apply to the organising secretary, RILEM Symposium, c/o Cement and Concrete Institute, Stockholm 70, Sweden.

***Indonesia International Trade Fair.**—Thurs., June 27, to Tues., Aug. 6, at Surabaya. Organised by the National Board of Indonesian Exhibitions, P.O. Box No. 2444, Djakarta, Indonesia.

Engineering, Marine, Welding and Nuclear Energy Exhibition.—Thurs., Aug. 29, to Thurs., Sept. 12, at Olympia, London, W.14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568.



At 2,000 r.p.m. the Newage/B.M.C. 5 litre Diesel engine develops 82 b.h.p.

FIVE LITRE DIESEL ENGINE

The most recent of the engines marketed by Newage (Manchester), Limited, 6 Carlos-place, Grosvenor-square, London, W.1, is the 5·1 litre Diesel in the Newage/B.M.C. range, shown in the illustration. It is a six-cylinder O.H.V. model with a bore of 95 mm. and stroke of 120 mm.; maximum brake horse-power at 2,000 r.p.m. is 82; maximum torque is 226 lb.-ft. at 1,500 r.p.m. The cylinder block is of cast iron, integral with the crank-case and fitted with detachable wet type cylinder liners in alloy cast iron. There are seven main bearings with shell-type replaceable steel-backed copper-lead half-bearings. A forged-steel crankshaft is used.

The camshaft is mounted in the side of the cylinder block in seven plain bearings. The engine is normally governed by a pneumatic governor attached to the injection pump set to a speed of 2,000 r.p.m., but a centrifugal governor can be fitted if required. Simms fuel-injection equipment is used. High-pressure lubrication is used throughout, provided by an oil pump gear-driven from the front end of the crankshaft. Circulation of the cooling water is by a centrifugal pump with a self-adjusting seal.

* * *

COAL TAR FUEL

Coal-tar fuels consisting of the heavier hydrocarbon oils, usually lumped together under the name "creosote," together with some residual pitch, form 80 per cent. of the products of tar distillation. During the war, a peak consumption of about 600,000 tons a year was handled and distributed by the Petroleum Board, representing at that time some 35 per cent. of the national consumption of liquid fuels for industrial purposes. This peak figure has once again been reached, but it is now only about 10 per cent. of the liquid-fuel consumption of industry.

Coal-tar fuels have been used for some time in steam-raising plant, and G.W.B. Furnaces Limited, P.O. Box No. 4, Dibdale Works, Dudley, Worcestershire, now report that one of their Powermaster packaged boilers has been effectively fired with CTF.200. This is a mixture of residual pitch and creosote oil in roughly equal proportions, having a viscosity somewhere between 1,000 and 1,500 seconds Redwood No. 1 at 100 deg. F., or of 100 seconds at 200 deg. F. The boiler using the fuel has a maximum output of 8,625 lb. of steam per hour, from and at 212 deg. F., and it has been found that fouling of the burners by the coal-tar fuel has only been slight. The preferable rate of cleaning of the burners is once a week.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

CROYDON
"Specialised Spot Welding," by C. G. Aldridge. South London Branch. Half Moon Hotel, Broad Green, Croydon. Thurs., Jan. 3, 8 p.m.

British Institution of Radio Engineers

LONDON
Films on "Radio and Electronic Engineering." London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Jan. 9, 6.30 p.m.

LIVERPOOL
"Instrumentation for Frequency Modulation," by D. R. Willis and A. G. Wray. Merseyside Section. Liverpool Chamber of Commerce, 1 Old Hall-street, Liverpool, 3. Wed., Jan. 2, 7 p.m.

MANCHESTER
"Projection Television Systems," by C. Somers. North Western Section. College of Technology, Sackville-street, Manchester. Thurs., Jan. 3, 6.30 p.m.

British Interplanetary Society

LONDON
"Astronomy and Earth Satellites," by Dr. Michael W. Ovenden. Caxton Hall, off Victoria-street, S.W.1. Sat., Jan. 5, 6 p.m.

Building Centre

LONDON
Film Display by Associated Lead Manufacturers Ltd. Wed., Jan. 2, 12.45 p.m.

Chemical Engineering Group

LONDON
"Use of Multi-Wall Paper Bags in the Chemical Industry," by A. R. Hutchinson. Society of Chemical Industry, 14 Belgrave-square, S.W.1. Tues., Jan. 15, 5.30 p.m.

Illuminating Engineering Society

LONDON
"Lighting as an Effective Aid to Architecture," by H. R. Ruff, H. E. Bellchambers and R. V. Mills. E.L.M.A. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Tues., Jan. 8, 6 p.m.

BIRMINGHAM
Display of Lighting Fittings. Birmingham Centre. Birmingham College of Technology, Suffolk-street, Birmingham. Tues., Jan. 1, 6 p.m.

CARDIFF
"Street Lighting in South Wales," by F. H. Pulvermacher; and "Eye Appeal," by W. G. Sweet. Cardiff Centre. Offices of the South Wales Electricity Board, The Hayes, Cardiff. Thurs., Jan. 3, 7 p.m.

EDINBURGH
"The Electrical Contractor's Approach to Artificial Lighting," by E. Cassidy. Edinburgh Centre. Y.M.C.A., 14 South St. Andrew-street, Edinburgh. Wed., Jan. 9, 6.15 p.m.

NEWCASTLE-UPON-TYNE
"Lighting of Small Factories," by J. S. McCulloch. Newcastle-upon-Tyne Centre. Department of Electrical Engineering, King's College, College-road, Newcastle-upon-Tyne, 1. Wed., Jan. 9, 6.15 p.m.

NOTTINGHAM
"Lighting of Standard Factories on Trading Estates," by J. S. McCulloch. Nottingham Centre. Electricity Service Centre, Smithy-row, Nottingham. Thurs., Jan. 3, 6 p.m.*

Incorporated Plant Engineers

LONDON
"Acoustics and Vibration," by W. A. Hines and D. C. Smart, London Branch. Royal Society of Arts, John Adam-street, W.C.2. Tues., Jan. 8, 7 p.m.*

EDINBURGH
"Electronics in Industry," by R. B. Smith. Edinburgh Branch, 25 Charlotte-square, Edinburgh. Tues., Jan. 8, 7 p.m.

PETERBOROUGH
"Dust Control," by R. J. Pitt. Peterborough Branch. White Lion Hotel, Peterborough. Thurs., Jan. 3, 7.30 p.m.

SOUTHAMPTON
Discussion on "Ship Construction." Southern Branch. Polygon Hotel, Southampton. Wed., Jan. 2, 7.30 p.m.

Institute of British Foundrymen

ACCRINGTON
"Hot Blast Cupolas," by J. Henderson. Burnley Section. Accrington College of Further Education, Sandy-lane, Accrington. Wed., Jan. 9, 7.30 p.m.

BRADFORD
"Pressure-Cast Aluminium Pattern Plates," by H. Howlett. West Riding of Yorkshire Branch. Technical College, Bradford. Sat., Jan. 5, 6.30 p.m.

DUNDEE
"Malleable Castings for the Engineering Industry," by H. J. M. Conacher. Scottish Branch. University College, Dundee. Wed., Jan. 9, 7.30 p.m.

SHEFFIELD
"Foundry Maintenance," by G. J. Jenkins. Sheffield Branch. Department of Engineering, College of Commerce and Technology, Pond-street, Sheffield. Mon., Jan. 7, 7 p.m.

Institute of Fuel

LONDON
"Approval Tests for Coke Burning Domestic Appliances," by W. A. D. Baker. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Jan. 2, 5.30 p.m.*

Institute of Marine Engineers

LONDON
"The Application of Research to the Design of Marine Steam Turbines," by Dr. T. W. F. Brown. Tues., Jan. 8, 5.30 p.m.*

BIRMINGHAM
"Reheating as a Contribution to the Economy of the Marine Steam Turbine, with Special Reference to the Installation in the T.S.S. Empress of Britain," by A. W. Davis. West Midlands Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Thurs., Jan. 3, 7 p.m.*

Institute of Metals

LONDON
"The Metallurgical Challenge of Nuclear Power," by Dr. H. K. Hardy. London Local Section. Thurs., Jan. 3, 6.30 p.m.*

BIRMINGHAM
Discussion on "Timber versus Metals," opened by D. O. Reece, W. E. Ballard and Dorothy Pile. Birmingham Local Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Thurs., Jan. 3, 6.30 p.m.

OXFORD
"Gases in Metals," by Dr. C. E. Ransley. Oxford Local Section. Cadena Café, Cornmarket-street, Oxford. Tues., Jan. 8, 7 p.m.

Institute of Petroleum

LONDON
Symposium on "Staff Training." Wed., Jan. 2, 5.30 p.m.*

Institute of Refrigeration

LONDON
"Thermal Properties of Heat Insulation at Low Temperatures," by M. J. Hickman. Junior Institution of Engineers, Pepys House, 14 Rochester-row, S.W.1. Thurs., Jan. 3, 5.30 p.m.*

Institution of British Agricultural Engineers

LONDON
"Economics of Machinery Investment on the Farm," by F. G. Sturrock and J. R. Warburton. Tues., Jan. 8, 5.30 p.m.*

BIRMINGHAM
"Requirements of Machinery Designed for Overseas Markets," by J. E. Mayne. West Midlands Centre. Chamber of Commerce, 95 New-street, Birmingham, 2. Mon., Jan. 7, 7.30 p.m.

Institution of Chemical Engineers

LONDON
"Solution of the Equations for Mass-Transfer in Plate-Type Distillation Columns," by H. H. Rosenbrock. Geological Society, Burlington House, Piccadilly, W.1. Tues., Jan. 8, 5.30 p.m.

Institution of Civil Engineers

LONDON
"Organisation and Control of Highways Maintenance," by W. J. Hiscock. Road Division. Tues., Jan. 8, 5.30 p.m.*
Vernon Harcourt Lecture on "Inland Waterways," by C. M. Marsh. Wed., Jan. 9, 5.30 p.m.*
"Application of Works Study to Railway Civil Engineering Maintenance," by P. D. T. Pescod and J. C. F. Cameron. Railway Division. Thurs., Jan. 10, 5.30 p.m.*

EDINBURGH
"Fertiliser Factory, Leith Docks," by J. P. A. Macdonald, L. Gordon and C. M. Wilson. Edinburgh and East of Scotland Association. North British Hotel, Edinburgh. Wed., Jan. 9, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough-gardens, London, S.W.1. (TATe Gallery 9371.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Engineering Group, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Refrigeration, New Bridge Street House, New Bridge-street, London, E.C.4. (CENtral 4694.)
Institution of British Agricultural Engineers, 6 Buckingham-gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers-in-Charge, 100 Earlsfield-road, London, S.W.18. (BATtersea 1394.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Leeds Metallurgical Society. Apply to Dr. P. Feltham, The University, Leeds, 2.
Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7 (KENsington 0048.)
Plastics Institute, 6 Mandeville-place, London, W.1. (WELbeck 5439.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
South Wales Institute of Engineers, Park-place, Cardiff. (Cardiff 23296.)
West of Scotland Iron and Steel Institute, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)

Institution of Electrical Engineers

LONDON
"A Theoretical and Experimental Investigation of Anisotropic-Dielectric-Loaded Linear Electron Accelerators," by R. B. R. Shersby-Harvie, L. B. Mullett and others. Joint Meeting of the Measurement and Radio Sections. Tues., Jan. 8, 5.30 p.m.*
"Some Aspects of Heat-Pump Operation in Great Britain, with Particular Reference to the Shinfield Installation," by Miriam V. Griffith. Thurs., Jan. 10, 5.30 p.m.*
BELFAST
"New Developments in High-Frequency Electric Motors," by C. Snowden. Northern Ireland Centre. Engineering Department, Queen's University, Belfast. Tues., Jan. 8, 6.30 p.m.
BIRMINGHAM
Discussion on "Recruitment to the Engineering Profession." South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Jan. 7, 6 p.m.*
BRIGHTON
"Crystal Palace Television Transmitting Station," by F. C. McLean, A. N. Thomas and R. A. Rowden. Southern Centre. Brighton Technical College, Brighton. Wed., Jan. 9, 6.30 p.m.
NOTTINGHAM
"Electrical Energy from the Wind," by E. W. Golding. East Midland Centre. College of Arts and Crafts, Waverley-street, Nottingham. Tues., Jan. 8, 6.30 p.m.

Institution of Engineering Designers

LONDON
"The Demands of Standards on Engineering Design," by E. W. Greensmith. Thurs., Jan. 10, 6.45 p.m.

Institution of Engineers-in-Charge

LONDON
"Automatic Level Control in Boilers," by C. G. Scolding. St. Bride Institute, Bride-lane, Fleet-street, E.C.4. Wed., Jan. 9, 6.30 p.m.

Institution of Heating and Ventilating Engineers

LONDON
"Mechanical Services in the Central Area of London Airport," by R. E. Tully. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Jan. 9, 6 p.m.*
NEWCASTLE-UPON-TYNE
"Some Notes on the Choice of Mechanical Stokers for Boiler Plants," by E. J. C. MacDonald. North East Coast Branch. North of England Institute of Mining and Mechanical Engineers, Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Jan. 7, 6.30 p.m.

Institution of Locomotive Engineers

LONDON
Film Evening. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., Jan. 3, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Discussion on "New Techniques of Photo-Elasticity." Applied Mechanics Group. Wed., Jan. 2, 6.45 p.m.*
"An Experimental Investigation of the Process of Expanding Boiler Tubes," by Dr. J. M. Alexander and Professor Hugh Ford. Meeting in conjunction with the Applied Mechanics Group. Fri., Jan. 4, 6 p.m.*
"A Review of Hydro-Kinetic Fluid Drives and Their Possibilities for the British Motor Industry," by J. G. Giles. Automobile Division General Meeting, in conjunction with the Hydraulics Group. Tues., Jan. 8, 6 p.m.*
BRISTOL
Film Evening. Western A.D. Centre. Royal Hotel, Bristol. Thurs., Jan. 3, 6.45 p.m.
LEICESTER
Annual General Meeting. "A Standard Gas Turbine to Burn a Variety of Fuels," by G. B. R. Feilden, J. D. Thorn and M. J. Kemper. East Midlands Branch. College of Technology and Commerce, Leicester. Wed., Jan. 9, 7.15 p.m.
NEWCASTLE-UPON-TYNE
Annual General Meeting. "An Approach to the Techniques of Graduate Training," by D. L. Marples, F. A. Radford and J. L. Reddaway. North Eastern Branch. Stephenson Building, Newcastle-upon-Tyne. Mon., Jan. 7, 6 p.m.

Institution of Production Engineers

LONDON
"Broaches and Broaching," by W. E. Soden. London Graduate Section. Tues., Jan. 8, 7.15 p.m.
CHATHAM
"Modern Gear Production," by H. J. Watson. Rochester Section. Sun Hotel, High-street, Chatham. Thurs., Jan. 10, 7.30 p.m.
CHELMSFORD
Discussion on "Electronic Computer Control of Machine Tools." South Essex Section. Mid-Essex Technical College, Chelmsford. Wed., Jan. 9, 7.30 p.m.
LEICESTER
"Mechanical Handling:" "Truck Methods," by R. A. Bishop; and "The Ohrnell System," by A. Brown. Leicester Section. Grand Hotel, Leicester. Thurs., Jan. 10, 7 p.m.
NOTTINGHAM
Graduates' Meeting. Nottingham Section. Victoria Station Hotel, Milton-Street, Nottingham. Wed., Jan. 2, 7 p.m.
STAINES
"Application of Accurate Measurement to Engineering Production," by J. Loxham. Reading Section. Social Club, Petters Ltd., Staines. Thurs., Jan. 3, 7.30 p.m.

Institution of Structural Engineers

BRISTOL
"The Advantages and Disadvantages of Structural Steelwork, Reinforced Concrete and Prestressed Concrete," by Donovan H. Lee. Western Counties Branch. New Engineering School, The University, Bristol. Fri., Jan. 4, 6 p.m.

Junior Institution of Engineers

LONDON
Film "Power for Uganda," introduced by Geoffrey F. Kennedy. Fri., Jan. 4, 7 p.m.*
BIRMINGHAM
Chairman's Address, by J. H. Price. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., Jan. 2, 7 p.m.
MANCHESTER
"Projection Television Receivers," by I. Somers. North Western Section. College of Technology, Manchester. Thurs., Jan. 3, 6.30 p.m.*

Leeds Metallurgical Society

LEEDS
"Some High-Temperature Properties of Copper Alloys," by Dr. J. P. Dennison. The Large Chemistry Lecture Theatre, The University, Leeds, 2. Thurs., Jan. 3, 7.15 p.m.

Physical Society

LONDON
"Thermal Properties of Heat Insulation at Low Temperatures," by M. J. Hickman. Low Temperature Group. Junior Institution of Engineers, Pepys House, 14 Rochester-row, S.W.1. Thurs., Jan. 3, 5.30 p.m.*

Plastics Institute

LONDON
"Plastics and the Engineer," by J. Butler. Lecture for young people. Church House, Westminster, S.W.1. Wed., Jan. 2, 2.30 p.m. (Admission, gratis, by ticket.)

Royal Aeronautical Society

LONDON
"Experiences of an Airline Pilot," by Captain O. P. Jones. Lecture for young people. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Thurs., Jan. 3, 3 p.m.
"Significance of Flow Separation in Three Dimensions," by E. C. Maskell. Section Lecture. Tues., Jan. 8, 7 p.m.

Royal Institution

LONDON
"Photography," by Dr. H. Baines. Six lectures for young people. Remaining lectures: Tues., Jan. 1; Thurs., Jan. 3; Sat., Jan. 5; and Tues., Jan. 8, at 3 p.m. in each case. (Admission by ticket.)

Sheffield Metallurgical Association

SHEFFIELD
Annual General Meeting of the Methods of Analysis Group, and Chairman's Address by W. Wright. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield, 3. Tues., Jan. 8, 7 p.m.

Society of Chemical Industry

LONDON
"Corrosion Problems in Nuclear Power Production," by A. B. McIntosh. Wed., Jan. 9, 6.30 p.m.

Society of Instrument Technology

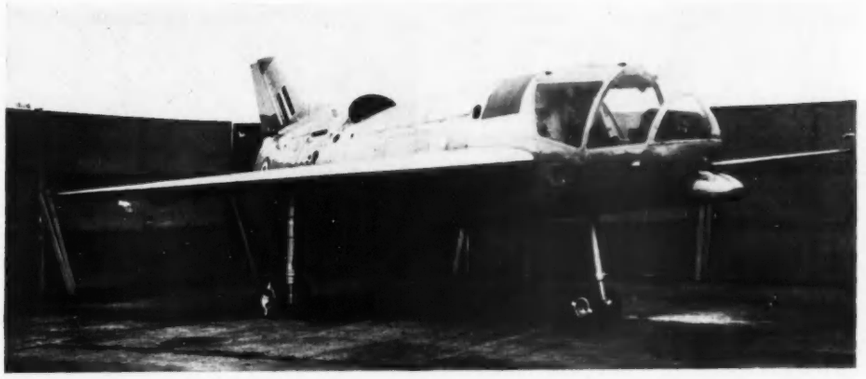
LONDON
"Electronic Automation of Machine Tools," by F. T. Lett. Control Section Meeting. Manson House, 26 Portland-place, W.1. Thurs., Jan. 10, 7 p.m.*
CHELTENHAM
Film Evening. Cheltenham Section. The Rotunda, Cheltenham. Mon., Jan. 7, 7.30 p.m.
FAWLEY
Discussion on "Position Displacement Meters." Fawley Section. Copthorne House, Fawley, Hants. Fri., Jan. 4, 7 p.m.
SHEFFIELD
"Some Applications of Instruments in the Coal Industry," by P. Platten. South Yorkshire Section. The University St. George's-square, Sheffield, 1. Wed., Jan. 9, 7 p.m.

South Wales Institute of Engineers

CARDIFF
"Drifting at Pentreclwydau Colliery," by E. J. H. Nicholas Thurs., Jan. 10, 6 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
"Metallic Recuperators," by W. Ernest and C. B. Tupholme. Fri., Jan. 11, 6.45 p.m.



The Short and Harland SCI is the first fixed-wing machine capable of taking off and landing vertically and transferring from hovering to forward flight while maintaining a conventional fuselage attitude throughout.

VERTICAL TAKE-OFF WITH A WINGED AIRCRAFT

Shown in the accompanying illustration is the vertical take-off research aircraft SCI, constructed by Short Brothers and Harland Limited, Queens Island, Belfast, the first fixed-wing machine capable of taking off and landing vertically and transferring from hovering to forward flight while maintaining a conventional fuselage attitude during vertical flight as well as in forward motion. The Convair XFY-1, which successfully achieved transition from vertical to horizontal flight some two years ago, is a "tail-sitter," that is, it takes-off and lands with the axis of the fugelage disposed vertically. The SCI carried out its first taxying trials in Belfast last week.

The SCI is powered by five Rolls-Royce RB 108 torbojets, about which no information has yet been released. It seems probable that one of these engines is disposed with its thrust axis horizontal, for forward propulsion; the other engines being arranged amidships to eject vertically downwards for take-off, landing and hovering; and that control would be achieved, as in the Rolls-Royce Flying Bedstead, by means of compressed air jets. The control system and the automatic stabiliser it is stated, were developed in conjunction with the Royal Aircraft Establishment.

The constructors state that the taxying trials are "the first step in an extensive programme of development leading to the attainment of jet-powered vertical take-off and landing." The next step will be to fly the SCI as a conventional aircraft, taking-off and landing in the conventional manner. When the aircraft is proved in forward flight, it will go on to vertical take-offs and landings, and transition from hovering to forward flight.

Short Brothers and Harland Limited foresee important applications in both military and civil aviation. The price to be paid, however, for the complete elimination of lengthy runways and costly airfields, in terms of aircraft weight and space, must be quite considerable, in spite of the great advances in specific thrust that the engine makers are achieving. For general applications the eventual development of the jet-flap principle (ENGINEERING, November 25, 1955, page 722) appears to hold more promise of economical operation. The main future of the pure vertical take-off machine would seem to be in carrier-borne operations or jungle warfare.

★ ★ ★

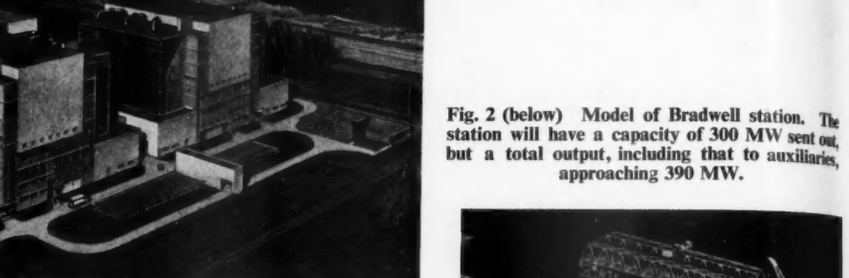
INTEGRAL SODIUM LAMPS

To the 140 watt sodium integral lamp introduced in June, 1956, there have now been added three more, rated at 45, 60 and 85 watts, together forming a full range of such lamps, manufactured by the General Electric Company, Limited.

The particular advantage of these lamps is that the entire starting mechanism is contained within the single envelope in a fully protected arc tube, and external apparatus such as has often been mounted at the foot of the supporting column has been dispensed with. Reliable starting is now obtained under all atmospheric conditions, and it is now reported that the lamps have been put into use in the metropolitan borough of St. Pancras, London. The fact that the control gear is integral with the lamp has proved of great benefit in this case since the existing columns on which the lanterns are mounted have insufficient accommodation for control gear in their bases. The sodium lamps will replace mercury-vapour lanterns.

Fig. 1 (left) Impression of the Bradwell nuclear power station as it will appear when completed. It is to be built by the Nuclear Power Plant Company, Limited, and will have 12 heat exchangers—6 per reactor.

Fig. 2 (below) Model of Bradwell station. The station will have a capacity of 300 MW sent out, but a total output, including that to auxiliaries, approaching 390 MW.



ATOMIC REVIEW

On the Eve

Britain may have highest nuclear power capacity in 1960—More details of the Bradwell and Berkeley stations—Contractors' contributions at Berkeley—Nuclear power station consultants for South of Scotland Electricity Board—Possible design for Somerset station—Details of fifth consortium—Nuclear energy conference—Compliments of the Season—Steamed up—Vital statistics—Corsetted pressure vessels—Science for the citizen.

Britain Leads

Britain will be ahead of the United States and U.S.S.R. in 1960 in atomic power generating capacity according to a survey published by the Raytheon Manufacturing Company, of Waltham, Mass., U.S.A. The order of countries for 1960 given by the survey is: Britain, the United States, the Soviet Union, Czechoslovakia, France, the Philippines, Sweden, Canada, the Dominican Republic and Belgium. Britain is placed first in expenditure on power reactors, though America will lead in terms of research, tests and experimental reactors. The placing seems rather curious, for in spite of a recent announcement by Mr. L. Strauss, chairman of the United States Atomic Energy Commission, that an expansion in the American programme is intended, the United States capacity is hardly likely to be raised from the earlier estimate of about 800 MW by 1960 to 2,000 MW, which is the minimum figure given in the Soviet five-year programme. The high position of the Philippines and the placing of Sweden before Canada also seem strange unless process heating plants (in the case of Sweden) are included in the total. Also, Britain's lead must be based on new plans which have not yet been formally announced. Nevertheless, it can be fairly certain that the survey is correct in placing Britain first; the existence of five nuclear power groups indicates that at least five stations (four sites have already been discussed) are initially planned, each in the region of 300 MW, which with the capacity of the Calder Hall and Chapel Cross plants bring the total capacity to more than 1,800 MW. In addition, it is likely that the Minister of Fuel and Power will announce a further expansion after the Christmas recess; in that case we may well exceed the existing Soviet proposals.

C.E.A. Nuclear Stations

Some further details of the first two nuclear power stations to be built in England have recently been published by the Central Electricity Authority. It is considered that few projects have been planned in so much detail as these stations, and as soon as construction begins the work should proceed to completion with a minimum of delay.

Bradwell.—The station to be situated at Bradwell-on-Sea, Essex, is to be built by the Nuclear Power Plant Company, Limited. It will occupy part of a site of approximately 142 acres and when completed will have an output of 300 MW sent out. The efficiency will be 28 per cent. The plant will consist of two natural uranium, carbon dioxide gas cooled graphite-moderated reactors supplying heat to 12 boiler units (heat exchangers). Six boilers will be associated with each reactor and will be placed in two groups of three on opposite sides of the reactor to form one complete unit. Steam from the boilers will be at two pressures: 755 lb. per sq. in. at 704 deg. F. (373 deg. C.), and 195 lb. per sq. in. at 704 deg. F., and will be used to drive six dual-pressure turbo-generators of 52 MW capacity. Two boilers are grouped to supply one set through a common receiver with interconnection of one set capacity between each of the six steam receivers. Each reactor core will comprise a vertical cylinder approximately 45 ft. in diameter by 31 ft. high, built up from graphite blocks and containing about 2,600 fuel channels. This core will be contained in a 3 in. thick spherical steel pressure vessel of some 66 ft. 9 in. diameter. The reactor will be surrounded by a concrete biological shield about 8 ft. thick. The fuel elements will comprise uranium rods just over 1 in. in diameter sheathed in magnesium alloy. Carbon dioxide gas at a pressure of 130 lb. per sq. in. gauge will transfer the heat produced in each reactor to its six associated boiler units through 5 ft. diameter ducts. Six variable-speed axial-flow blowers, each connected to the outlet of a boiler, will discharge the gas into the reactor vessel. Three 20 MW variable-speed turbo-generators, one being a standby, are to be used for supplying power to the blower drives which are standard induction motors.

The six main turbines will run at 3,000 r.p.m. and will be dual-pressure machines provided with twin exhausts, the back pressure being 0·54 lb. per sq. in. They will drive standard hydrogen-cooled alternators generating at 11·8 kV, feeding into generator transformers with a ratio of 11·8/132 kV and will be switched at 132 kV. The total output, including that to auxiliaries is 390 MW. Two station transformers and six unit transformers will be provided. Circulating water will come from the River Blackwater, and to prevent re-circulation, a baffle wall will be built at the intake, the intake being on the river side of the wall with the discharge on the shore side of the wall. The longitudinal centre line of the turbine house runs parallel with the centre line passing through the two reactors. The relative positions of the reactors, cooling pond and turbine house form a combination of features which provide for the most economical siting and rapid erection procedure. In addition to workshops, offices, stores and canteens, there will be other services housed in the reactor building or in ancillary buildings; these will comprise a decontamination section, fuel store, change rooms, laundries, effluent treatment plant and health physics laboratories. There will also be a solid active waste disposal area. The compact arrangement of the reactor buildings has made it possible to employ a Goliath crane, 40 ft. in height, 167 ft. span, and of 200 tons capacity, to assist in the erection of the plant.

The control of the station will be from one central control room in which will be housed the usual electrical equipment, reactor and boiler control board, and turbo-generator control. From this point it will be possible to monitor the whole of the plant and make all essential adjustments necessary for smooth and efficient operation. The reactors will be refuelled on load, a small number of fuel channels being replenished almost every day. The irradiated fuel which is removed from the reactors will be stored on site in a cooling pond for several months before being collected by the U.K.A.E.A., and taken to one of their chemical factories where the plutonium and fission products will be extracted. An impression of the Bradwell station appears in Fig. 1, and a sectioned model in Fig. 2.

Berkeley.—The Berkeley station, in Gloucestershire, is to be built by the A.E.I.—John Thompson Nuclear Energy Company, Limited, and will occupy part of a site of approximately 96 acres. It will cost between £30 million and £40 million, and when completed will have an output of 275 MW sent out. It should be completed in 3½ years. The plant will consist of two natural uranium, carbon dioxide gas cooled, graphite-moderated reactors supplying heat to 16 boiler units (heat exchangers), eight boilers being associated with each reactor and grouped round it to form a complete unit.

Each boiler unit will be contained in a cylindrical steel pressure shell approximately 70 ft. high by 17 ft. 6 in. in diameter, and will raise steam at two pressures: 306 and 62 lb. per sq. in. gauge. Both high-pressure and low-pressure steam will be superheated to 612 deg. F. (321 deg. C.). Steam from the boiler units will be used to drive four dual-pressure turbo-generators of rather more than 80 MW capacity. Each reactor core will comprise a vertical cylinder approximately 48 ft. in diameter by 30 ft. high, built up from graphite blocks and containing about 3,000 vertical fuel channels. This core will be contained in a 3 in. thick cylindrical steel pressure vessel some 50 ft. in diameter by 80 ft. high. The reactor will be surrounded by a concrete biological shield having a thickness of about 8 ft. The fuel elements will comprise uranium rods just over 1 in. in diameter sheathed in magnesium alloy and refuelling will take place on load, a few channels being replenished each day. Carbon dioxide gas at a pressure of 125 lb. per sq. in. will transfer the heat produced in each reactor to its eight associated boiler units through 5 ft. diameter ducts. Eight variable-speed axial-flow blowers driven by induction motors through hydraulic couplings will be connected to the outlet of each boiler, and will discharge the gas into the reactor vessel.

The four turbo-generators will be 3,000 r.p.m. machines designed to accept steam at the two pressures generated by the boilers. They will have triple exhausts designed for a back pressure of 0·43 lb. per sq. in. The generators will be hydrogen cooled and will generate at 11·8 kV. They will feed 11·8/132 kV transformers, and will be switched at 132 kV. Two station transformers and four unit transformers will be provided. Circulating water will be provided from the River Severn and to prevent re-circulation a baffle wall will be built at the intake, the intake being on the river side of the wall with the discharge on the shore side of the wall. The longitudinal centre line of the turbine house runs parallel with the centre line passing through the two reactors. As in the case of the Bradwell station, the relative location of the reactors, cooling pond and turbine house form a combination of features which provide for the most economical siting and rapid erection procedure. Services and control are similar to those for the Bradwell station. A sectioned model of the projected Berkeley station is illustrated in Fig. 3.

Contractors at Berkeley

The civil engineering contractors for the Berkeley station are Balfour Beatty and Company, Limited, and John Laing and Son, Limited. John Laing's part amounts to £4½ million and includes the building work on the reactors and steam-raising plant, and the construction of such ancillary works as the fuel element and carbon dioxide stores, waste and effluent disposal plants, temporary works and buildings (such as batching plants and the precast-concrete yard), roads and services. The construction of the reactors entails excavation amounting to 250,000 cub. yds.; bending and fixing 4,100 tons of reinforcement; placing 80,000 cub. yds. of high-quality concrete and 40,000 cub. yds. of lean-quality concrete; and the erection of 1,200 tons of structural steel. Each reactor has two blower houses and two operation annexes. The foundations are 36 ft. below finished ground level and the reactor-building roof is 154 ft. above ground level. The major part of the civil engineering and building works for the first reactor has been planned for completion in two years, and for the second reactor in two and a half years.

The part of the contract to be carried out by John Thompson Limited will have a value of £10 million to £11 million. This includes manufacture and construction of the large reactor vessels, each 50 ft. in diameter, 80 ft. high and weighing 1,000 tons. Steel plate for these vessels, 3 in. thick, will be processed and rolled in sections at Wolverhampton and welded on site. Thermal shielding for the reactors, in the form of 4 in. steel plate will also be fabricated at Wolverhampton. John Thompson will also make the gas-cooling circuits and heat-exchange towers, of which there are eight to each of the two reactors. These heat-exchange towers are about 17 ft. 6 in. in diameter and 70 ft. high. They will embody a total of some 150 miles of tubing.

The British Thomson-Houston Company, Limited, will be responsible for the design and manufacture of such large items as the 16 gas circulators (eight for each of the two reactors). These are in the form of axial compressors, each being driven by a 2,980 r.p.m. A.C. motor of more than 3,000 h.p., through variable-speed couplings. B.T.H. will also make more than 900 auxiliary motors ranging from 750 h.p. to fractional horse-power sizes, and totalling about 22,000 h.p. The entire control gear for these motors and the H.T. (6,600 volts), L.T. (415 volts) and D.C. (240 volts) switchgear required for the extensive auxiliary distribution system supplying them are to be of B.T.H. manufacture. The same company will also build the four large 11/132 kV generator transformers (to step up the generator output voltage to national grid level), together with all the transformers necessary for providing the 6·6 kV and 415 volt auxiliaries, the rectifiers to feed the station D.C. busbars, and four 600 kW D.C. generators for Diesel-driven standby sets. The reactor control-rod actuators are all of B.T.H. design and manufacture and there will be at least 150 per reactor. These fulfil the dual function of controlling the nuclear power and providing quick shut-down in emergency. The British Thomson-Houston Company will supply almost all the equipment for the central control room, including a considerable proportion of the special instrumentation, and complex safety systems.

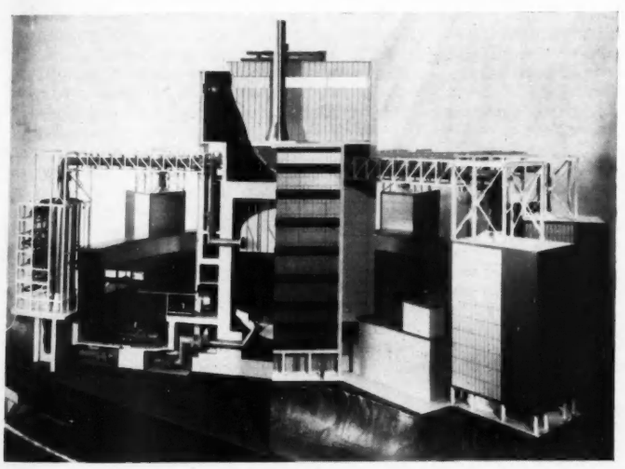


Fig. 3 A sectioned model of the projected Berkeley nuclear power station, which will have 16 heat exchangers—8 per reactor. It is to be built by A.E.I.—John Thompson Nuclear Energy Company, Limited.

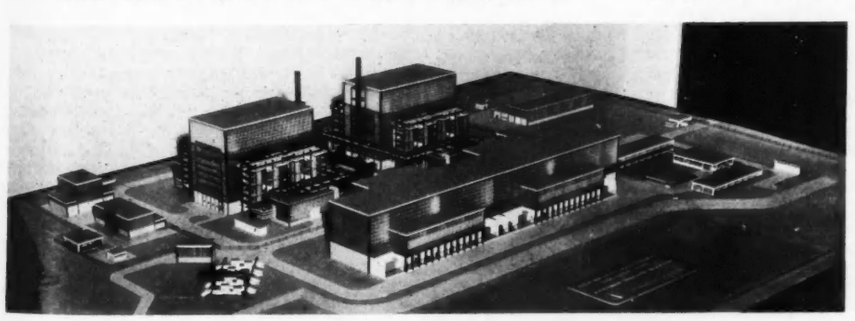


Fig. 4 Model of the nuclear power station design submitted by the English Electric—Babcock and Wilcox—Taylor Woodrow group. A station basically similar may be built in Somerset.

South of Scotland Consultants

The consultants to the South of Scotland Electricity Board for the nuclear power station to be built by the G.E.C.—Simon-Carves group (ENGINEERING last week) are Kennedy and Donkin, 12 Caxton-street, London, S.W.1.

Somerset Station

A third site is under consideration by the Central Electricity Authority for a nuclear power station; this is at Inkley Point in Somerset. (In all, this makes four projects in the United Kingdom including the G.E.C.—Simon-Carves contract for the South of Scotland Electricity Board.) Last month the C.E.A. announced that, subject to the requisite planning permission and approval by the Minister of Fuel and Power, they propose to erect their third nuclear power station in Somerset. They are in negotiation with the English Electric-Babcock and Wilcox-Taylor Woodrow group of companies and, if satisfactory agreement is reached in this respect, they intend to proceed with construction at this site as soon as possible after planning approval and consent for the project are obtained. A model of the power station design previously submitted by the group is shown in Fig. 4. The third C.E.A. station may be similar in most respects to this design.

Fifth Group

As previously reported in ENGINEERING, a fifth consortium of companies prepared to undertake nuclear power station work has now been established. Details are announced concerning the group, which has been formed after consultation with the United Kingdom Atomic Energy Authority and the Central Electricity Authority, to tender for the design and supply of atomic power stations for the United Kingdom and abroad. The companies which comprise the group, and their respective interests in the design and construction of nuclear power stations, are: Richardsons Westgarth and Company, Limited (generating plant including turbo-alternators, blowers and standby generators); International Combustion (Holdings) Limited, who will undertake the building of the steam-generating equipment, including the reactor, heat exchangers and pressure vessels; and Crompton Parkinson Limited (switchgear, transformers, cables and motors). Each of these concerns is already established in the construction of plant for conventional power stations. The new organisation will be accommodated centrally in an office block recently constructed at 28-30 Theobalds-road, London, W.C.1. The group will operate through a joint company, Atomic Power Con-

structions Limited, with an authorised capital of £1,000,000. The board of Atomic Power Constructions Limited comprises The Rt. Hon. Lord Coleraine, P.C., as chairman; Mr. Harry Fothergill, a director of Richardsons Westgarth; Mr. J. Mayer, joint managing director of International Combustion; and Mr. J. V. Daniel, managing director of Crompton Parkinson.

Notice

A conference—"The 1957 Nuclear Energy Conference"—is to be held from March 11 to 15, 1957, in Philadelphia. The sponsors are the Engineers Joint Council. An international atomic exhibition is also to be held.

Morning After

Now that we have reached the convalescent stage of Christmas and entered the limbo between that festival and the beginning of the New Year, we can perhaps pause a moment in this last issue of 1956 to recover our equilibrium. Yet it is difficult to determine what departures from routine in recognition of the season, if any, are appropriate to a technical journal. A common practice is to look back over the past year, highlighting important events; but for the writer, at least, it is a laborious task and often unfruitful. In any case, what of significance has happened during the last 12 months? Admittedly, we have seen the opening of Calder Works, but this is, after all, only the second nuclear power station in the world, and perhaps even the third, depending whether we read *Pravda* or the *Missouri Tribune*, and whether we measure power in watts or megawatts. Alternatively, we might have neglected atomic energy entirely for one week, providing a welcome respite; but fearing that like the victims of a certain executioner it never "would be missed", we hastened to log our usual entry. This week therefore we have followed our normal practice, though there may of course be aberrations.

Hot Water

Anyone who thinks of a motor car as a device for boiling water is likely to be disappointed with its efficiency. There are some who have similar feelings about nuclear reactors. The boiling-water reactor certainly has its advocates, but we have yet to learn whether a system of this kind can be built and operated economically. The problem of fabricating suitable fuel elements remains outstanding, and although the Americans are planning the construction of large plants based on versions of the boiling system, we have no evidence yet that they will prove satisfactory. The decision to undertake a project does not mean that all the technical problems have been solved. It was only after the installation of a sodium-cooled reactor in the United States submarine Seawolf that the severity of corrosion and leakage problems became apparent. It is understood that replacement with a pressurised-water reactor is now envisaged. True, the boiling-water reactor is inherently safe; but it is not inherently stable owing to irregular formation of bubbles in the core, though certain versions may secure an improvement in this feature (see ENGINEERING, November 23, page 669). In addition, like the pressurised-water reactor, it is subject to the corrosive attack of water at high pressures and temperatures. There is clearly more to be said about the boiling system; and it would be interesting to hear the arguments pro and con.

Facts and Figures

We have it on good authority (*Nucleus*, a bi-monthly publication issued from Windscale), that the concrete used at Calder Hall would be sufficient to make one decent road between Seascale and the Windscale factory, the by-pass around Doncaster and two 500 ft. statues of Gina Lollobrigida (290-190-270).

Pressure-Vessel Girdles

There can be no doubt that engineers profit from ideas evolved in alien fields, though it is not always easy to know what ideas have already been considered and rejected. "Why," we were asked by an engineer concerned with cables and packing cases, "don't they try putting bands round the pressure vessels for nuclear reactors? They could then achieve both strength and rigidity without being limited by the thickness of plate that can be welded on site." We were reminded that the pressure vessels carrying the fuel for certain rockets were strengthened in this way, looking rather like golf balls with the covers off. We didn't know the answer, but wonder if on this scale the increase in strength would in fact be commensurate with the cost.

The Elastic Band Theory

So much technology is nowadays based, though often insecurely, on a foundation of scientific theory, that we feel the need for more than a vague idea as to what scientific theory is. Each advance of the physicist seems one step farther from our familiar world, much as successive abstractions by the artist produce results increasingly unintelligible to the viewer who has not been present at every stage. It would be interesting to know whether the theoretical scientist believes his concepts to be facts, or merely working rules, models or analogies, useful for the time being. Are his theories about small particles and the universe intended as an approach to an ultimate reality, or are they just a convenience to reconcile or even simply to catalogue his data?

We have therefore evolved our own theory about theory. Data or observations, we suggest, may be represented by a number of cylindrical pegs of various diameters, as illustrated in Fig. 5. Theory is the elastic band which binds them. There will of course be spaces in which further pegs can be inserted; in other words we can predict discoveries before they are made, as Dirac established the existence of the positron, before it was observed, and Einstein predicted certain apparent inconsistencies in the position of stars, which also proved to be the case. After a time, data may appear that do not fit conveniently into any of the spaces, and it is necessary to stretch the elastic band in order to accommodate them. Eventually the band breaks and someone is called upon to replace it. Thus Einstein, faced with anomalies, in terms of classical mechanics, concerning the observed motion of the planet Mercury and the constant velocity of light relative to the earth, whatever its motion, was led to formulate his famous theory.

If we accept the elastic band view, we are compelled to regard no theory as nearer to or further from the truth than another but merely embracing more or less. It might even lead us to suspect—but here we should be treading in paths untrod by angels—that prediction and subsequent discovery were in fact an elaborate tautology arising from the nature of things. The succession of prophecy and fulfilment would then no more confirm the efficacy of scientific reasoning than the intricacy of a butterfly's wing is evidence of a grand design. To the layman, Einstein's approach appears very much that of reconciling phenomena rather than describing a deeper reality. Thus an essential of Relativity seems to be that since you can't observe simultaneity, it must be excluded from consideration. But the layman is bound to continue to believe in the occurrence of simultaneous events whether they can be checked or not, much as he does not need to meet Sir Anthony Eden to believe in his existence.

Professor W. Ross Ashby, if we understand him correctly, has suggested that we may reach a stage in science, at least in some fields, where data are too numerous and too complex to be embraced or understood as a whole, and theories in these cases are therefore impossible. This is particularly true of systems in which there is a high degree of heterogeneity (large quantities of dissimilar data) and extensive internal interaction. This second condition means that many factors are influenced by others, as for example in sociology; thus in systems of this kind, unlike electrical networks, where currents tend in general to ignore each other, the principle of superposition is not permissible. In other words, the approach of changing one variable while the others are held constant is excluded. Professor Ashby maintains that the limit to the understanding of data occurs when the complexity of the data exceeds the complexity of the observing channel, or, less accurately, of the scientist himself. In fact eventually, it will be necessary, Professor Ashby suggests, to feed our data into a computer as it reaches us, particularly where the subject matter is enormous and diverse as in social or biological studies, and so obtain results without understanding how they are reached. Programming the computer would not necessarily involve a grasp of the inherent relationships within the data.

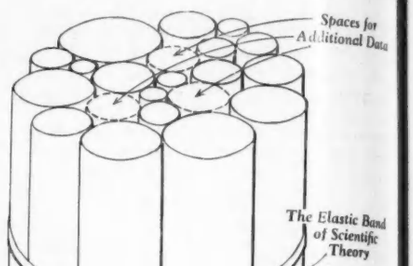


Fig. 5 The elastic band of scientific theory.

Given the elastic band interpretation of scientific theory, however, the problem of complexity does not arise, since we are then only concerned with working rules, and can choose our scientific "level" in accordance with the subject matter. Thus to study the brain in terms of kinetic theory and nuclear physics would bring to the problem unnecessary complexity; but in neurological or psychological terms it becomes much more manageable; and in these studies approximation is thoroughly acceptable. Indeed, human beings are highly complex, but men generally achieve a sufficient understanding of their wives (a working rule at least) to get through life without being entirely overwhelmed with surprises.

Unfortunately the elastic-band theory leads to an unhappy position. "If you regard our neutrinos and mesons as merely convenient fictions," says the physicist, "where are you going to draw the line? Our approach is, after all, only an extension of common sense, and it does give results. You'll be claiming next that the gas laws are an illusion, the internal-combustion engine a fiction, technical civilisation a dream, and the whole world a figment of your own imagination. That path leads to madness." In answer it may be said that the problem doesn't in fact arise; whether we imagine it or really experience it, our environment continues to behave with due respect for habit and tradition. For example, we may say that since the policeman doesn't really exist we can jump with impunity on his toe. Unfortunately, whether illusory or real, the sensations that follow will not be pleasant. The distinction is thus indeterminable, and as with simultaneity we can conveniently ignore it. Thus, we have to recognise that science is not concerned with distinctions where no distinction can be determined, phenomena that cannot be observed, and quantities that cannot be measured. This, in fact, is where we came in.

Postscript

"Natural science and technology form an inseparable whole."

Max Planck.

In Parliament

TOO LITTLE NUCLEAR POWER

As was only to be expected, of course, the present shortages of oil have served to increase the attention which is being given in Parliament to the country's nuclear power programme and, in the Commons last week, Mr. Aubrey Jones, the Minister of Fuel and Power, was under pressure from various quarters to make a statement. In general, the feeling appeared to be that not enough progress was being made.

The Minister told the House that the Government were anxious to expand the nuclear power programme as far as, and as fast as, they could do so practicably and that, to this end, they were urgently reviewing the position. When Mr. William Warbey (Labour) commented that a promise had been made many months ago to issue a statement on an expanded atomic power programme as soon as tenders for the new power stations had been examined, Mr. Jones replied that he had undertaken to endeavour to make a statement before the end of the year. He was sorry that the study of the situation was not quite concluded but he would make a statement as soon as the Christmas recess was over. In answer to Dr. R. F. B. Bennett (Conservative), who felt that the Minister was not likely to be criticised, either in the House or by the country, for going too far in expanding his programme, Mr. Jones repeated that the Government would proceed as far and fast as they could, but stressed that the progress to be made was limited by what was practicable.

Captain G. R. Chetwynd (Labour) welcomed the announcement of the latest award of contracts, which, he said, was very much in advance of what had been anticipated, but inquired why a statement could not be made that, as far as possible, the present programme would be doubled. Was it a lack of technical skill or of money which was holding up the statement? On the question of finance, Mr. James Callaghan (Labour) pointed out that there were very grave anxieties pressing on those persons who had to make decisions on a commercial basis, and proposed that the Government should provide some of the capital required, in order that the programme should not be delayed.

In regard to these suggestions, Mr. Jones said that there were several aspects of the nuclear power programme to be taken into account: technical skill, raw materials and, of course, capital expenditure. All these requirements had to be examined and, clearly, that examination could not be done in too great a hurry. He did not wish to prejudge the question of the Government providing capital, but there would not be any delay in dealing with these matters.

TWO MINISTERS OR ONE?

Another aspect of the nuclear power programme was raised by Mr. A. M. F. Palmer (Labour/Co-operative). He inquired as to what action had been taken by the Minister of Fuel and Power, in the national interest, to ensure that an effective liaison had been established between the Central Electricity Authority and the Atomic Energy Authority, in order to advance the programme with the least possible delay. Would the Minister care to say, he asked, whether it was true that there had been strong differences of opinion between the two Authorities regarding the programme? If such were the case, was it not an argument for having one Minister in charge of these matters instead of two.

Mr. Jones said that the two Authorities had made arrangements to keep in the closest touch with each other on all aspects of the programme and that his Ministry was associated with them both in the urgent study now being given to the expansion of the programme. In his experience, he had never yet known any body of people in whom there had been no disagreement, but he did not think that, whatever disagreements there might have been, they had affected the amity of the relations between the two bodies. The question of whether there should be two Ministers or only one touched, Mr. Jones said, upon much larger issues.

In answer to Dr. Bennett, who asked the Lord Privy Seal about the types of nuclear reactor likely to be selected for power stations under the enlarged programme for commercial nuclear energy, Mr. R. A. Butler said that the reactors in the early nuclear power stations would be of the same type as those at Calder Hall. Their capacity, however, would be considerably increased. Reactors of this type were believed to be capable of further development and should hold the field for some years. The Atomic Energy Authority was studying a number of other reactor systems for possible application in the later stages of the nuclear power programme, but it was not yet possible to indicate which of these types were the ones likely to be selected.

LAGGING COAL PRODUCTION

Subsequently, the House turned its attention to coal production and supplies. Mr. Palmer pressed the Minister to state what steps he was taking to avoid difficulties arising in industry and trade this winter, owing to fuel shortages resulting from the estimated increase of two million tons in the national requirements of coal, consequent upon the decline in oil imports. He asked if Mr. Jones was confident that he could deal with the situation which might conceivably arise should the weather in January and February prove very severe, and whether coal supplies, particularly at power stations, were adequate.

Mr. G. Nabarro (Conservative) raised similar issues. He also drew attention to the domestic side of the problem and asked for details of any additional coal purchases which had been authorised from the United States. Coal production, he said, showed no increase and, indeed, was actually decreasing in some respects. Mr. Angus Maude (Conservative) wanted the Minister to give a general direction to the National Coal Board to take urgent action to speed up the production of deep-mined coal.

In reply, Mr. Jones said that, granted the level of imports arranged for the winter and granted the level of stocks, he did not think that further imports would be required. The situation would be kept under review, but the level of stocks now was extremely favourable. The special position of the coal industry would certainly be taken into account in respect to the distribution of oil to that industry. Apart from any increases in manpower, there must be an acceleration of the rate of investment and an improvement in labour relations if coal production was to be increased. There had been a quickening of the rate of investment both as to mechanisation and reconstruction, and it would be noted that the miners' leaders had recently joined the Board in publicly declaring that they would take all possible measures, during the next six months, to secure a better spirit in the industry.

COAL FROM AFRICA

A request was made by Mr. Maude to the Minister to state what steps he was taking to secure additional supplies of coal from countries in the sterling area. How much of this coal, Mr. Maude asked, did the Minister expect to be made available to this country, and when? Mr. Paul Williams (Conservative) wanted to know what conclusions had been reached about the development of coal deposits in Africa. It was pointed out that it was six months since Mr. Jones had first told the House that the subject of importing coal from Africa was being urgently studied by the Ministry of Fuel and Power.

On these points, Mr. Jones said that he knew of no supplies of coal at present available which could be imported economically into the United Kingdom from sterling areas. The Government had not yet completed their consideration of the issues involved in the possibility of developing Commonwealth coal reserves in Africa. It was less than six months since he had endeavoured to make it clear to the House that the importation of coal from Commonwealth sources in Africa was a matter which concerned other Government Departments besides his own. It was, in fact, an inter-departmental issue. The problem involved embarking upon investments which could not be expected to yield returns in under ten years. In these circumstances, six months was not an exaggerated time to take in considering the matter.

Civil Service Engineers and Scientists

In answer to a question by Dr. B. Stross (Labour), about the number of engineers and scientists in the higher Civil Service, Mr. Henry Brooke, the Financial Secretary to the Treasury, said that there were about 1,160 in the higher grades. This number was between 9 per cent. and 10 per cent. of the total number of scientists and professional engineers at present in the Civil Service.

Apprentice Education in Scotland

The problem of the low percentage of apprentices in Scotland who avail themselves of the day-release classes was raised by Mr. J. McInnes (Labour), who asked what consultations the Secretary of State for Scotland had had with employers and the trade unions on this matter. Mr. James Stuart replied that he had consulted bodies representative of both employers and trade unionists, such as the Regional Advisory Councils for Technical Education, the Scottish Council (Development and Industry), and the Scottish Board for Industry. He was glad to say that they were willingly co-operating in trying to persuade both sides of industry of the importance of taking full advantage of these classes.

Demands for Water

Technical information regarding the water resources of most parts of England and Wales has been collected by the Ministry of Housing and Local Government and is available to water companies and the local authorities concerned. Mr. J. Enoch Powell, the Ministry's Parliamentary Secretary, informed Mr. Cledwyn Hughes (Labour) that, at the request of the Minister, a sub-committee of the Central Advisory Water Committee was inquiring into the growing demand for water, and the problems involved in meeting it. The Minister had recently urged upon the bodies concerned the importance of building up stronger administrative units in the water industry by undertaking re-grouping arrangements.

Working Conditions at the Docks

According to a reply by Mr. Iain Macleod, the Minister of Labour, to Captain R. A. Pilkington (Conservative), comments from the various interested parties on the Devlin report on the national dock labour scheme are now being awaited. When these were received, Mr. Macleod said, consideration would be given, in consultation with the port transport industry, to the desirability of amending the scheme so as to give effect to the recommendations made in the report.

Car Exports to the Commonwealth

Mr. A. R. W. Low, Minister of State to the Board of Trade, informed Dr. Somerville Hastings (Labour) that the main difficulties of the motor industry in Commonwealth markets this year had arisen from the intensification of import restrictions in Australia and New Zealand. The President of the Board had told the Governments of both those countries of the serious situation which confronted the British motor industry and had made clear to them how helpful any relaxation in their import restrictions on motor vehicles would be. Over the bulk of the motor-car trade, the restrictions on imports into the Union of South Africa did not damage British sales, according to his information. Exports to the other principal Commonwealth markets, with the exception of those to India and Pakistan, were not subject to restrictions.

THE HUMAN ELEMENT

Statesmenship from the trade unions—Pay claims in the New Year—" Hidden " pay increases for miners—Management possibilities in the small firm—The D.S.I.R. grant to the N.I.I.P.

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Government and the T.U.C.

The remark in the House of Commons by Mr. Butler in a recent debate on social legislation that " the Government valued its contacts with the T.U.C." raises once again the difficulty the Council faces in co-operating effectively with a Government with whose policy it is in profound disagreement. The fact that Ministers and trade union leaders can get round a table at all under such circumstances and hold worthwhile conferences, is of a tribute to British compromise and to a touching faith in the efficacy of committees.

There is more to this liaison than the wish of a Tory government to use velvet gloves with labour's most representative organisation. The T.U.C. takes its role of industrial statesmanship very seriously. Its moves to take part in politics in a mild way and to carry its influence into international affairs carry a flavour of prestige for senior trade union officials which they savour. The achievements of the T.U.C. are in fact particularly marked in matters which have a political colour, especially in the colonial and international fields. The reasons for this are not far to seek. In purely trade union affairs in this country, it sits on top of independent and mature trade union organisations, many of which are much older than itself. It is therefore circumscribed in union matters in the United Kingdom. Abroad, it is filling something of a vacuum—or at least dealing with its own equals with similar problems to itself. Its achievements in this direction have often been impressive.

It has still to learn however (and the price might be suspicion among the rank and file) how to work with one political party while remaining affiliated to another.

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A.E.U. Ca'Canny?

The next move by the engineering unions in their demand for higher wages has been scheduled for January 10, when the national executives of the 40 unions concerned are to meet at York. It had been expected that the engineering workers would be less intransigent in their demands than the railway workers and this impression is now hardening. There is an idea gaining currency that the engineering unions will take an award of something in the region of 4 per cent., and that they will be prepared to wait for such an outcome from an arbitrational tribunal. Such a compromise percentage, and the possible absence of duress from the side of labour, will not be easy for the employers to resist. It will have an air of sweet reasonableness about it which men who wish to stand pat on their proclaimed decision to give nothing away at all will find difficult to turn down.

The timing of the York conference may be critical. Early in January, A.S.L.E.F. is expected to give its decision on the 3 per cent. increase offered some time ago to its members. On the A.S.L.E.F. decision will probably hang the decision of the N.U.R. on a similar offer made to it this week by the British Transport Commission, and the state of relation between the B.T.C. and the two railway unions could have a profound effect on the general climate of industrial relations in the early months of 1957.

There are indications that the international situation has curbed to some extent—if only temporarily—the militancy of some trade unionists, but the lull could be short-lived if there were a noticeable rise in prices in the next few months as the Suez blockage works itself out on the economy.

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Temporary Agreement on Coal Bonuses

A temporary agreement has been reached between the National Coal Board and the National Union of Mineworkers about bonus payments for the sixth shift. This agreement will last for six months, after which the claim of the union will be reconsidered. Meanwhile, if a miner works all available shifts for five consecutive weeks and then loses not more than one shift in a week he will not lose the full bonus for that week, unless his absence has been strike action.

The union are trying to get the payment for the sixth shift (which is paid for but not worked—hence the bonus element) spread over the other five shifts. The Board have resisted it as they think it would lead to absenteeism on an even bigger scale. Both sides have agreed to conduct a campaign for a better spirit in the coal fields between now and the time when the claim is reconsidered.

Labour relations in the coal fields are a law to themselves. The union's proposals would be quite unacceptable in other industries. Bonuses cease to mean anything if they are divorced from incentives, but this is what the miners are proposing should happen. They are clearly seeking to misuse words to get a rise in their basic pay, claiming attendance money in the name of a bonus. The nature of the compromise suggests that the miners will win their point in six months time. It may be desirable for them to get an increase, but it is also possible that the industry is making future trouble and confusion for itself by tying the increase to a bonus stripped of incentive.

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Trust the Boss

Yet another engineering company have abandoned piece-work payments for time rates, this time in Birmingham. The manner in which this was done, " without the aid of any documentary instrument, or signature, or guarantee, or trade union advice or intervention," is a striking example of what can be achieved even in our modern times of elaborate employer-union organisation and procedure by sheer force of leadership. Mr. Francis B. Willmott, chairman and managing director of Francis B. Willmott, Limited, found that piece-work payment made for inflexibility in employment resulting in short-time working and redundancy. It became increasingly difficult to keep all daywork (time rate) personnel fully employed on the basis of a four-day working week by piece-workers. Mr. Willmott therefore " sold " his piece-workers the idea of a daily rate, and reinstated a five-day week of 44 hours for everyone. The rate of pay has been related to previous earnings, divided into two grades only. The only condition, which was accepted by the men, was that each man would be " expected to be mobile, to become adaptable to any job in any part of the factory." In order to make it possible to cost each job—particularly important with new jobs—operations will continue to be timed and the work of each man will be recorded daily as before.

Mr. Willmott must be a dynamic person—the way in which he effected the change and his statement on it are evidence of that. He must also be an autocrat with supreme self-confidence. He says " if miracles can be performed I will do it," but an autocrat who is trusted to do the impossible is likewise likely to be given all the latitude he needs to perform his miracles. From all accounts, plenty will be needed to keep the whole work force fully employed on a five-day week.

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Psychology

A grant for the study of human factors in productivity has been made by the Department of Scientific and Industrial Research to the National Institute of Industrial Psychology. The amount is small—£8,000 maximum for a period of three years—and is related to the amount of grant-earning income in the form of membership subscriptions and special contributions towards the general research programme which the Institute can raise from industry. Nonetheless, it is a most valuable addition to the Institute's income and a welcome extension of the D.S.I.R.'s interest to the scientific study of human as well as technical problems.

The N.I.I.P. was founded in 1921 " in order to increase scientific knowledge of the factors bearing on the health, happiness and effectiveness of people at work." Since the war, major studies have been carried out on the operation of various forms of joint consultation: status, selection and training of foremen; the human problems created by repetitive work; and the training of factory operatives for semi-skilled jobs. In addition to its basic research programme, the Institute provides advice on the selection, allocation, training and up-grading of staff and workers; on working methods and equipment; and on communications and relationships within an organisation.

Commenting on the widespread belief that the problem of productivity in this country is largely a human one, the Institute says " It is not so much a question of people working harder as of working more effectively, from the managing director to the shop floor, to accept new ideas and new methods." In its efforts to find ways of making workers more effective the Institute has already achieved a great deal and it deserves continued support from industry.

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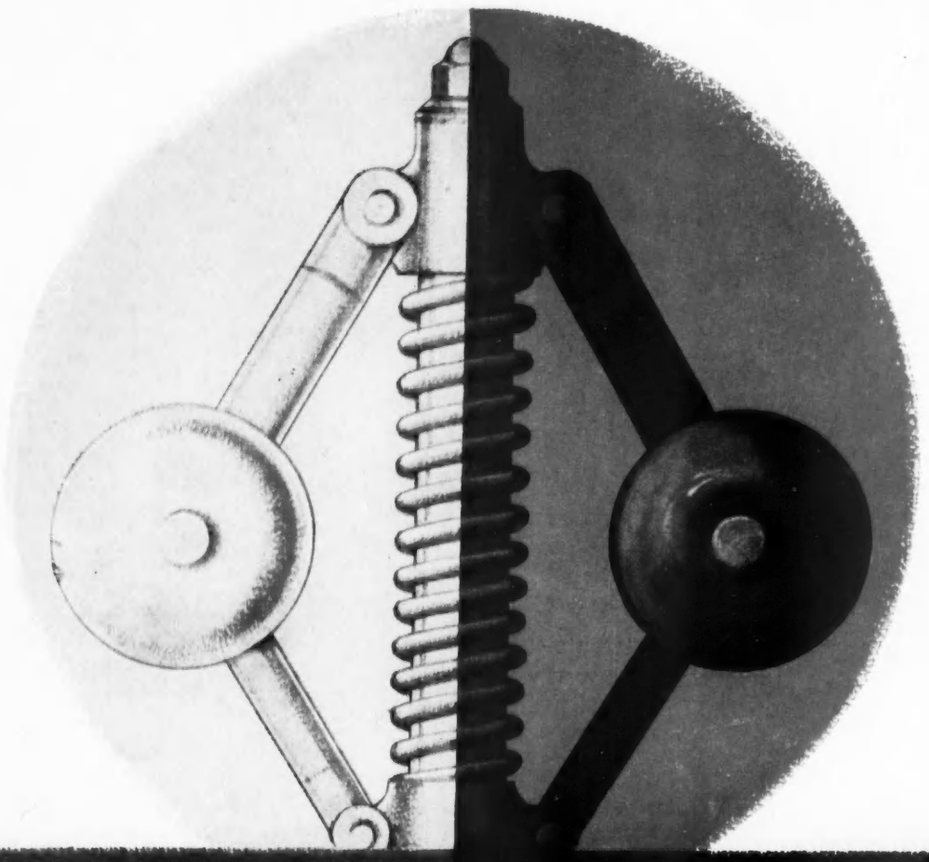

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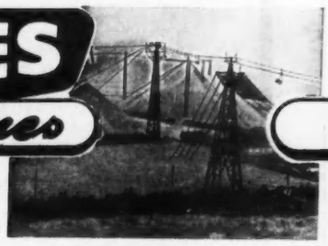

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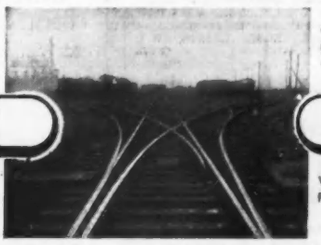

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For all advertisements classified under the headings of Tenders, Appointments Open, Situations Wanted, Patent Agents, Partnerships, Wanted, &c., Auction Sales, Publications For Sale, Miscellaneous and Public Notices, &c., the charge will be 12s. for the first four lines or under and 3s. per line up to one inch. When an advertisement measures an inch or more, the charge will be at the rate of 36s. per inch. 5% allowed on 6, 10% on 13, 15% on 26 and 20% on 52 Weekly insertions. If use is made of a box number the extra charge is 2s. per insertion with the exception of advertisements appearing under Situations Wanted. Prospectuses and Notices of Company Meetings £25 per column. Copy instructions must be in our hands first post Monday for the following Friday's issue. Address to the Manager, ENGINEERING LTD., 35 and 36, Bedford St., Strand, W.C.2. Inclusion of advertisements must be dependent on space being available.

FELLOWSHIPS.

UNIVERSITY OF EDINBURGH.

Applications are invited for

I.C.I. RESEARCH FELLOWSHIPS IN BIO-CHEMISTRY, CHEMISTRY, ENGINEERING, PHARMACOLOGY, PHYSICS OR CHEMICAL TECHNOLOGY, to which some appointments will date from 1st October, 1957 (or earlier in the case of selected candidates who may be available before that date). The Salary will depend upon qualifications and experience, but will normally be within the range £600 to £900 per annum, together with F.S.S.U. benefits and family allowance. Forms of application and further particulars may be obtained from the undersigned.

Applications (two copies) should be submitted not later than 16th Feburary, 1957.

CHARLES H. STEWART,
SECRETARY TO THE UNIVERSITY.
P 361

EDUCATIONAL

FREE! BROCHURE giving details of courses in Mechanical and Production Engineering, Draughtsmanship, etc., for the A.M.I.Mech.E., A.M.I.P.E., City and Guilds and other Professional examinations. **B.M.I. Institutes, Dept. EG30, London, W.4. (Associated with H.M.V.)** G 675

EXPERIMENTAL WORK

RESEARCH ENGINEERS LIMITED,

Northampton Grove, Canonbury, London, N.1. Canonbury 4244/5/6. We have over 25 years' experience of experimental work and prototypes. We design, develop and manufacture special purpose and labour saving machines, all at the above address. Our range is from the smallest scientific instruments to 3- or 4-ton machines. After a prototype machine has been made and found satisfactory we can manufacture as many as are required. G 658

FOR HIRE

LATTICE STEEL ERECTION MASTS (light and heavy) 30 ft. to 150 ft. high, for immediate hire. —BELLMAN'S, 21, Hobart House, Grosvenor Place, S.W.1. G 72

CONSULTANTS

DESIGN CAPACITY AVAILABLE

We have teams available to undertake design, detailing and development in the following fields:

Mechanical Engineering
Aeronautical Engineering
Special Machines and Projects
Servo Mechanisms and Automation
Mechanical Handling
Plant Layout
Production Tooling
Chemical Plant
Structure and Reinforced Concrete, Etc.

The conception, design and development of **"BLUEBIRD"** was a special project undertaken by

NORRIS BROTHERS LTD.
53, VICTORIA STREET, S.W.1
—TEL. ABBey 5444—

62, CHURCH ROAD,
BURGESS HILL, SUSSEX.
TEL. BURGESS HILL 3656
G 661

TENDERS

NEW TENDERS FOR YALLOURN "E" POWER STATION VICTORIA, AUSTRALIA

Notice is hereby given that the date for return of **TENDERS** for Yallourn "E" Power Station has been extended from 13th February, 1957, to 13th March, 1957.

Details of the Tenders were advertised in the issue of this paper dated November 30th, 1956.

STATE ELECTRICITY COMMISSION OF VICTORIA
22 William Street, Melbourne
P 379

REVISED ADVERTISEMENT.

BEDFORD CORPORATION WATERWORKS WATER DEPARTMENT.

CONTRACT "D."
NEW WATER TREATMENT WORKS AND PUMPING STATION.

The Corporation invite **TENDERS** for the construction of Clapham Road Treatment Works which includes the **CONSTRUCTION OF A RIVER INTAKE AND CULVERT, SCREENING CHAMBERS, SETTLING TANKS, FILTER WASHWATER TANK, FILTERED WATER RESERVOIR, PUMP SUCTION WELLS AND PUMP ROOM, LIME STORAGE HOPPERS AND GENERAL ADMINISTRATIVE AND CHEMICAL TREATMENT BLOCK.** With the exception of the river intake, culvert and the filter washwater tank, all these structures will be contained in one building, the New Treatment Works, which will be capable of treating water from the River Great Ouse at the rate of 6,000,000 gallons per day.

The whole of the works are situated on the Clapham Road, approximately two miles north of Bedford.

Drawings may be seen and the Documents obtained on application to G. H. HILL & SONS (MANCHESTER) CIVIL ENGINEERS, 51, MOSLEY STREET, MANCHESTER, 2, upon deposit of a cheque for Five Guineas. This sum will be returned to the Tenderer provided that he shall have sent in a bona fide Tender and shall not have withdrawn same.

Copies of the drawings are available, and if the Tenderer so desires, will be supplied to him on payment of the sum of Two Guineas, which will not be returned.

Alternatively, Documents and Drawings may be inspected at the office of the Water Engineer, Mill Street, Bedford.

Separate cheques should be sent made payable to G. H. Hill & Sons (Manchester).

Sealed Tenders, endorsed Contract "D" should be delivered to the Town Clerk, Bedford, on or before noon on the 30th day of January, 1957. ATTENTION IS DRAWN TO THE REVISED DATE OF SUBMISSION OF TENDERS.

The Corporation do not bind themselves to accept the lowest or any Tender.

G. F. SIMMONDS,
TOWN CLERK.
TOWN HALL,
BEDFORD. P 356

PUBLIC APPOINTMENTS

TRAINING OFFICERS required by N.C.B.'s Industrial Relations Dept., at London H.Q. to assist the Heads of Sections responsible for:—

(*a*) Training schemes for mineworkers (X524G).
(*b*) Apprenticeship schemes, specialised training of craftsmen and training of industrial workers in the Board's ancillary undertakings (X525G).

Applicants for (*a*) should have a knowledge of training activities including First Aid and preferably some mining experience, and for (*b*) experience of industrial training schemes preferably with a technical background would be an advantage. Appointments (superannuable) according to qualifications and experience within inclusive scale £1006-£1286 (male).

Write, with full particulars of age, education, qualifications and experience, to NATIONAL COAL BOARD, STAFF DEPT., HOBART HOUSE, LONDON, S.W.1, marking envelope with relevant X reference number before 4th January, 1957. P 354

UNITED KINGDOM ATOMIC ENERGY AUTHORITY ENGINEERS

required for

DESIGN AND DEVELOPMENT WORK AT ALDERMASTON, BERKS.

To work as members of a team engaged upon the design and development of mechanical, electro-mechanical and electronic equipment of unique and unorthodox design. Applicants should have served a recognised engineering apprenticeship and be corporate members of the Institution of Mechanical or Electrical Engineers or have exempting qualifications. For the senior posts applicants should have had at least three years' experience in the design of mechanical, electro-mechanical and/or electronic equipment.

SALARY: Engineer (Main Grade): £1235-£1655 p.a.
Engineer (Basic Grade): £775 (at age 25)-£1060 (at age 34 or over)-£1210 p.a.

Contributory Superannuation Scheme. A house or assistance towards legal expenses on house purchase will be available for married officers living beyond daily travelling distance.

Requests for application forms by POSTCARD to SENIOR RECRUITMENT OFFICER, ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON.
Please quote Ref. 135/26. P 353

LONDON COUNTY COUNCIL.

ARCHITECT'S DEPARTMENT.

Vacancies for

ENGINEERING ASSISTANTS (up to £818) and **ENGINEER GRADE III** (up to £987) in the Structural Engineering Division. Work includes steelwork and reinforced concrete design and detailing for Council's buildings. Particulars and application forms from ARCHITECT (AR/EK/SE/1), THE COUNTY HALL, S.E.1. (1278) G 573

LIVERPOOL REGIONAL HOSPITAL BOARD.

Applications are invited for the post of **REGIONAL ENGINEER.** Candidates, who should be corporate members of the Institution of Mechanical Engineers or the Institution of Electrical Engineers, must have had wide experience of engineering design and operation, preferably for hospitals or other large undertakings.

The Regional Engineer will be required inter alia to undertake the design and supervision of capital projects in the Board's major plant replacement programme and of new engineering works for which the Board is responsible (subject to the employment in some cases of consultant engineers) and to advise Hospital Management Committees on engineering problems.

The salary scale is £1690 by £80 (5) by £45 (1) to £2135 per annum and the post is superannuable.

Applications, stating age, qualifications and experience, together with the names of three referees should reach the undersigned not later than 5th January, 1957.

VINCENT COLLINGE,
SECRETARY TO THE BOARD.
19, JAMES STREET,
LIVERPOOL, 2. P 360

NOTTINGHAMSHIRE EDUCATION COMMITTEE.

WEST NOTTINGHAMSHIRE DIVISIONAL EXECUTIVE.
MANSFIELD TECHNICAL COLLEGE.

Principal: R. F. BEATON, B.Sc. (Eng.), Wh.Sch.

Applications are invited for the following new appointments.

TWO LECTURERS IN ENGINEERING SUBJECTS.

Applicants should be capable of teaching one or more of the following subjects to the level of the Higher National Certificate in Mechanical or Civil Engineering.

Thermodynamics.
Strength of Materials.
Theory of Machines.
Metrology and Machine Tools.
Metallurgy.
Workshop Technology.
Surveying.
Geology and Soil Mechanics.
Structural Design.
Engineering Materials.

Candidates should hold graduate or equivalent qualifications and have had appropriate industrial and preferably some teaching experience.

Salary in accordance with the Burnham Technical Scale for Lecturers, £1200 by £30 to £1350 per annum.

Forms of application may be obtained from (s.a.e.) and should be returned to the DIVISIONAL EDUCATION OFFICER, EDUCATION OFFICE, MARKET PLACE, MANSFIELD, within two weeks of the appearance of this advertisement. P 365

PUBLIC SERVICE OF SOUTH AUSTRALIA

Applications for the undermentioned position should be made in writing to the AGENT-GENERAL FOR SOUTH AUSTRALIA, SOUTH AUSTRALIA HOUSE, MARBLE ARCH, LONDON, W.1, setting out full names, address, date of birth, marital status, academic qualifications, practical experience, and particulars of war service (if any). Copies of testimonials and a photograph should be submitted with the application.

CHIEF ENGINEER.
Salary: £A3026 per annum.

Applications are invited for the position of Chief Engineer of the South Australian Harbours Board, a State Ports Authority charged with the administration, development and maintenance of the seaports of Adelaide, Pirie, Wallaroo, Lincoln and Thevenard and also 50 minor outports.

Applicants should be not more than 50 years of age, holders of approved University degrees in engineering, or corporate members of the Institution of Civil Engineers, London, or Institution of Engineers, Australia, who have specialised in port and harbour engineering.

The Chief Engineer will have responsibility for an engineering organisation at present numbering approximately 100 staff and 650 other employees, undertaking the design, construction and maintenance of engineering works and port installations. These include wharves and piers in reinforced concrete, steel and timber; retaining walls in steel sheetpiling and reinforced concrete; piled foundations, steel framed transit sheds and port buildings generally; the mechanical equipment of wharves including electrically-operated wharf cranes for general and heavy duty; electric power and lighting; major bulk coal and grain handling installations; breakwaters and earthworks. He will also be responsible for a fairly large dockyard engineering establishment; the maintenance and operation of a considerable fleet of dredgers, tugs, barges and other floating plant; the execution of major dredging and reclamation works; the installation and maintenance of aids to navigation; and the use and upkeep of a wide range of construction plants.

Administrative capacity of a high order and ability to lead and co-ordinate the work of other qualified engineers are essential qualifications.

The Chief Engineer is directly responsible to the General Manager, who is due to retire in March, 1961. P 366

ELECTRICAL INSTRUCTORS required at N.C.B.'s Mines Mechanisation Training Centre, West Bar Sheffield. A thorough knowledge of the design, installation, repair and operation of surface and underground electrical equipment is required; teaching experience and possession of H.N.C. (Electrical) or equivalent would be an advantage. Appointment (superannuable) according to qualifications and experience within range £725 to £850 male.

Write, with full particulars of age, education, qualifications and experience to NATIONAL COAL BOARD, STAFF DEPT., HOBART HOUSE, LONDON, S.W.1, marking envelope X/528/G, before 14th January, 1957. P 364

QUEEN MARY COLLEGE (UNIVERSITY OF LONDON), MILE END ROAD, E.1, invites applications from University graduates for a **LECTURESHIP IN MECHANICAL ENGINEERING.** Applicants should have a good engineering degree and some experience in industry and research. Salary scale, £700 by £50 to £1000 by £50 to £1400, initial salary according to qualifications and experience, with F.S.S.U. participation and family allowance of £50 for each child.—Application forms, to be returned within two weeks of appearance of this advertisement, obtainable from the REGISTRAR. P 381

APPOINTMENTS OPEN

HEAT TRANSFER AND FLUID FLOW Research and Development Engineer required by an old-established Engineering Company in the Glasgow area. Applicants, aged 25-30, should have a University Honours Degree in Engineering and some research experience. The work would involve the theoretical design and practical testing of new types of heat exchanger. A good salary would be paid to an applicant with the necessary qualifications. —Apply giving age and full particulars to BOX G 388, Offices of ENGINEERING.

DEVELOPMENT ENGINEER required. Age 30 or under. Sound engineering experience including shop work. Minimum qualifications O.N.C. or Inter BSc. and studying for H.N.C. or B.Sc. Able to use own initiative on production plant problems, controlling design and fabrication. At least A.E.S.D. rates rising to attractive ceiling. Good accommodation prospects. Non-Contributory Pension and Contributory Life Assurance schemes. Generous canteen facilities.—Please write stating age experience, qualifications, etc., to PERSONNEL MANAGER, NABISCO FOODS LTD. (FORMERLY THE SHREDDED WHEAT CO., LTD.), WELWYN GARDEN CITY, HERTS. P 289

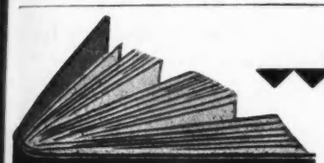
SENIOR MECHANICAL ENGINEERING DRAUGHTSMEN required for interesting work on large chemical plant installations. Experience in this type of work is desirable but not essential, applicants with general mechanical engineering experience will be favourably considered. The posts offer excellent opportunities with generous salaries commensurate with experience and ability. Offices situated in the N.W.1 London area. Five-day week and superannuation scheme.—Applications, which will be treated in confidence, should give previous experience and qualifications and be addressed to THE CHIEF DRAUGHTSMAN, LAPORTE CHEMICALS LIMITED, CLIFTON HOUSE, EUSTON ROAD, LONDON, N.W.1. P 251

BILLINGHAM ICI DIVISION

MECHANICAL ENGINEERING DRAUGHTSMEN
and
CIVIL ENGINEERING DRAUGHTSMEN

IMPERIAL CHEMICAL INDUSTRIES LIMITED, BILLINGHAM DIVISION,

offer attractive salaries in respect of several vacancies for each of the above classes of draughtsmen. Candidates must possess as a minimum qualification, the appropriate Higher National Certificate or its equivalent. Participation in Staff Pension Fund and Profit-Sharing Scheme. Financial assistance towards removal expenses available for married men. Without commitment, write for Application Form to the STAFF MANAGER, IMPERIAL CHEMICAL INDUSTRIES LIMITED, BILLINGHAM DIVISION, BILLINGHAM, CO. DURHAM, quoting reference R.17 G 666



Data on Fans and Ventilation

Woods Practical Guide to Fan Engineering

by W. C. Osborne and C. G. Turner

has filled a gap in engineering bibliography

Informative reference on ventilation requirements, heat losses; fan selection, performance and design system resistance, noise in fan systems, hazardous conditions.

227 pages 9in. by 6in. Bound full cloth Price **12s. 6d.**

Also French Edition: *Price* £1 17s.

From all Booksellers or from

WOODS of COLCHESTER LTD., Colchester, Essex

S. SMITH & SONS (ENGLAND) LTD.

Have the following vacancies:-

ENGINEERS.

Mechanical—with at least 5 years' practical experience, preferably in design and/or testing of Indicating Instruments or associated equipment. H.N.C. but preferably A.M.I.Mech.E.

Electrical—with at least 3 years' practical experience, preferably in testing Electrical Instruments and/or Electro-magnetic mechanisms. H.N.C. preferably Grad.I.E.E.

DEVELOPMENT ENGINEER : with practical drawing office and design experience, for development of small mechanic or electro-mechanical mechanisms, H.N.C. but preferably A.M.I.Mech.E.

PROCESS PLANNING ENGINEER : with experience of instrument manufacture. Able to layout machine processes from drawings. H.N.C. standard or equivalent in workshop practice.

SUPERVISION ENGINEERS : to supervise production of instruments to specification. O.N.C. standard in Electrical or Mechanical Engineering.

SENIOR DESIGN DRAUGHTSMAN : with experience of instruments or light engineering. Minimum qualifications, 3 years design experience; O.N.C. standard. Monthly status for right man. Older man with good press tool experience considered.

JIG & TOOL JUNIOR DRAUGHTSMAN : with practical tool experience for assembly and test.

ESTIMATOR : with practical background and knowledge of production operations and work study. O.N.C. standard.

WORK STUDY ENGINEER : fully experienced with Machine Shop and Metal Finishing background.

TECHNICAL ASSISTANT : with knowledge of radio and some administrative experience. O.N.C. standard or equivalent.

MATERIALS APPLICATION ASSISTANT : with experience of material specifications, able to do trigonometry. Engineering background.

●

All these positions are progressive and only those able to command good salaries should apply to :

MR. SQUIRE, CRICKLEWOOD WORKS, N.W.2
GLA 3333.

P 375

A NUMBER OF DESIGNERS AND DRAUGHTSMEN are required for good class mechanical engineering work by HEENAN & FROUDE, LIMITED, WORCESTER.

Applicants should be between the ages of about 25 and 40. Please state education, training, experience and salary required; special consideration to men with outstanding experience and qualifications. Those used to aircraft test plant, marine, medium and heavy engine designing would be particularly suitable. Pension Scheme, attractive surroundings, and usual staff amenities Assistance with housing and removal expenses, if necessary.

Please address your application for the attention of MR. T. SALTER. P 334

PROJECT ENGINEER.

AVELING-BARFORD, LTD., invite applications for the position of Project Engineer, responsible to a Director for co-ordinating design and development to ensure the introduction by planned dates of new products in the Earthmoving and Allied Fields. The position is one in which individual drive and initiative will be required in directing a project team drawn from Technical and Production Departments. Essential basic qualifications are: a degree or equivalent in mechanical or civil engineering, experience in the design or development of mechanically propelled vehicles, and workshop experience. Minimum age, 30. The salary envisaged is not less than £1000 per annum, dependent on experience and qualifications.

Please apply, giving full details of education, qualifications and experience to THE SECRETARY, AVELING-BARFORD, LIMITED, INVICTA WORKS, GRANTHAM, LINCS. P 380

Classified Advertisements continued on Page 83

The Efficiency of Adhesives for Wood

Summaries, for easy reference, of four series of tests to determine the suitability of various types of glue in wooden joints for use in a wide range of environments. **2s. 6d.** (*post* 2*d.*)

Chemical Engineering in the U.S.A.

BY P. M. CALDERBANK

Some observations resulting from a survey made in 1955

2s. (*post* 2*d.*)

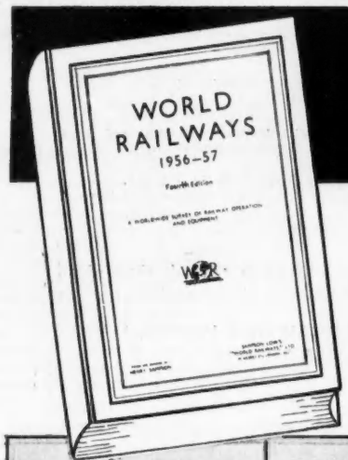
HMSO

from the Government Bookshops or through any bookseller

EVERYONE "Looks it up in-"

WORLD RAILWAYS

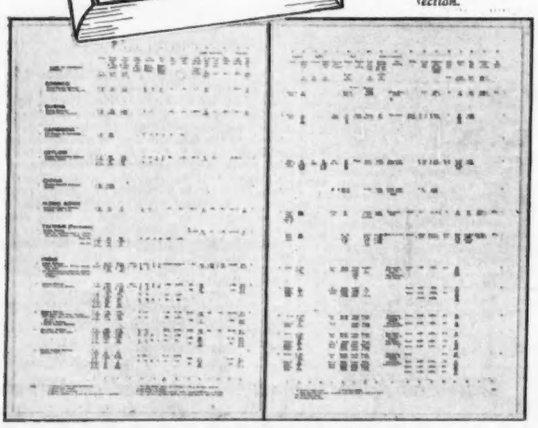
The only illustrated world survey of railway operation & equipment

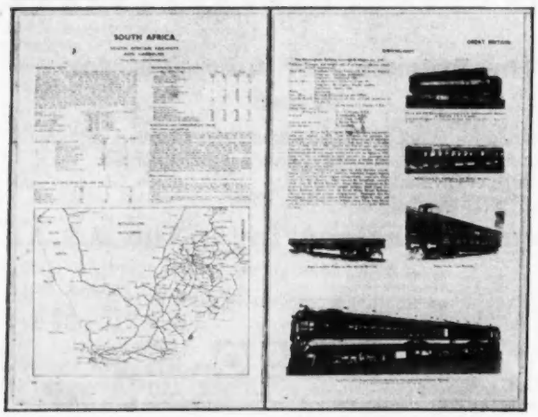


4th EDITION NOW READY

EDITED BY HENRY SAMPSON

Size 12¾×8¼ in. 500 pages. Below are miniature reproductions of two of the tabular pages, a page from the progress survey of a major railway, and a page from the manufacturers' section.





Tabulated details of all railways in each country for easy comparison of any feature

32 tabular headings, 1470 railways in 106 countries.

Progress and projects of major railway administrations

In addition to exhaustive equipment and operation information (rolling stock totals, financial and traffic details, etc.) special attention is devoted to electrification, future trends and welded rails. Occupies 354 pages, includes 490 illustrations, maps and diagrams.

Activities and production of world's locomotive and rolling stock builders

Covers 171 companies in 88 pages and contains 285 photographs.

Specifications of world diesel engine builders' products available for rail transport use

Diesel engines from 50 h.p. to 2,400 h.p. produced by 51 companies are described in 42 pages with 71 photographs.

Illustrated surveys of developments of special interest

Radio and Electronics in Rail Operation, Long-welded rails and Flexible Rail Fastenings, Lightweight Trains.

£4 4s. 0d. net. Please send for illustrated brochure containing specimen pages, or request your bookseller to obtain a copy for your examination.

SAMPSON LOW, 25 GILBERT STREET, LONDON, W.1

QUALITY

This letter was recently addressed by us *to users of steel castings.* It fairly represents our views about the quality of steel castings and equally, it pinpoints the *real interests of the user.*

Manifestly, it is not the price of a steel casting in the 'as-cast' condition that really matters, it is the final cost when the casting is machined and assembled that is the *real cost* of a steel casting, and it is upon this latter cost that price comparisons should be made.

As we said in our letter, we feel sure that users will agree that this is sound commonsense, and we welcome enquiries on these terms. We make carbon steel castings up to 2 tons in weight.

Admiralty Contractors since 1808
On Admiralty and Lloyds List

Brown, Lenox & Company Limited

Associated Company: Brown, Lenox & Co. (London) Ltd. Millwall, E.14

PONTYPRIDD, GLAMORGAN

Telephone: PONTYPRIDD 3031-2-3
Telegrams: 'LENOX', PONTYPRIDD

MAKERS OF STEEL CASTINGS, GENERAL ENGINEERS AND SPECIALISTS IN THE MAKING, REPAIRING AND TESTING OF CHAIN AND OTHER LIFTING GEAR

YOUR REF.
OUR REF

Messrs. Palmer Tilen & Co.
Mill Lane Station Road,
Uxbridge.

4th February, 1957

Dear Sir,

STEEL CASTINGS

How can a steel founder best serve the interests of his customer? Our answer to this question is that, as steel founders, we should compete for our customers' goodwill and orders primarily in terms of quality of product.

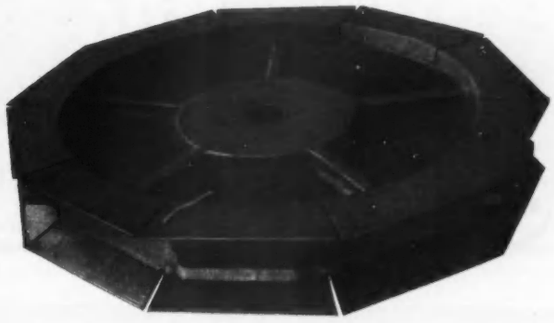
Steel is poured into a mould at a temperature which is in the region of 1650°C, a very high temperature; as it 'freezes' steel contracts in volume by just over 11%. Need more be said to demonstrate what is involved in making a steel casting sound and dimensionally accurate except, of course, those of very simple shape and arrangement.

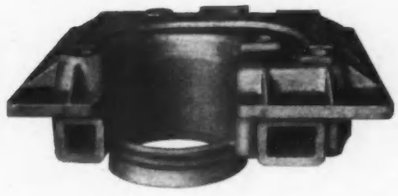
The 'price factor' as it applies to a steel casting is not a straightforward issue of how much you pay for a casting "as cast", but instead, how much does the casting finally cost when it is machined and assembled; it is that final cost we aim to reduce to a minimum.

We feel sure that you will agree that this is good sound commonsense and we should like to have your enquiries on these terms. We specialise in carbon steel castings up to 2 tons in weight.

Yours faithfully,
for BROWN, LENOX & CO. LTD.

H. A. LENOX
Director





BROWN, LENOX & COMPANY LIMITED

Associated Company: Brown, Lenox & Co. (London) Ltd., Millwall E.14

PONTYPRIDD GLAMORGAN

SM LIMITED

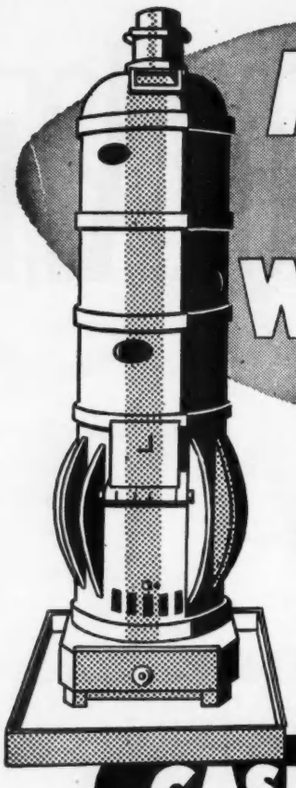
Makers of

The WIDEST STEEL SHEETS

BLACK & GALVANISED . . .

FOR ALL PURPOSES . . .

SMITH & McLEAN · LTD
179 WEST GEORGE ST · GLASGOW · C·2
'PHONE CENtral 0442 · 'GRAMS "CIVILITY" GLASGOW



KEEP *at low cost* WARM

BURNS ANYTHING COMBUSTIBLE

These highly efficient slow-combustion stoves will be in greater demand than ever this winter.

MADE IN 2 SIZES	No. 1	No. 2
Diameter	22 in.	18 in.
Height	6 ft.	5 ft. 4 in.
Heating Capacity	25,000 cu. ft.	18,000 cu. ft.
12 hrs. Fuel ...	75 lb.	56 lb.
Price ... ... Nett	£38 3s. 0d.	£32 4s. 0d. Carriage extra.

CASHMORES

JOHN CASHMORE LTD.
SM/IC 2020

GREAT BRIDGE, TIPTON, STAFFS.
Tel.: Tipton 2181 (5 lines)

NEWPORT, MON.
Tel.: Newport 66941 (6 lines)

TUNGUM BRAND ALLOY
Trade Mark

IN UNIVERSAL USE

TUBE
ROD
BAR
SHEET
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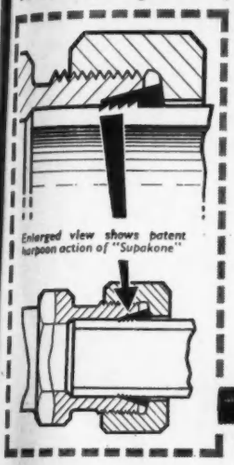
GAUZE
WIRE-ROPE
CASTINGS
to A.I.D.
and A.R.B.
specifications

THE TUNGUM COMPANY LIMITED · CHELTENHAM · ENGLAND

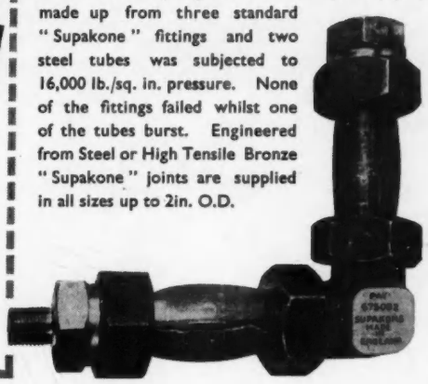
Supakone
PAT. NO. 672,082 (REG. D)
HIGH PRESSURE FITTINGS

FOR HYDRAULIC, AIR, STEAM AND OTHER SERVICES

Need only a spanner for a perfect joint



Combining maximum efficiency with a simplicity of action, a "Supakone" joint can be made or unmade with only a spanner. The test piece (right) made up from three standard "Supakone" fittings and two steel tubes was subjected to 16,000 lb./sq. in. pressure. None of the fittings failed whilst one of the tubes burst. Engineered from Steel or High Tensile Bronze "Supakone" joints are supplied in all sizes up to 2in. O.D.



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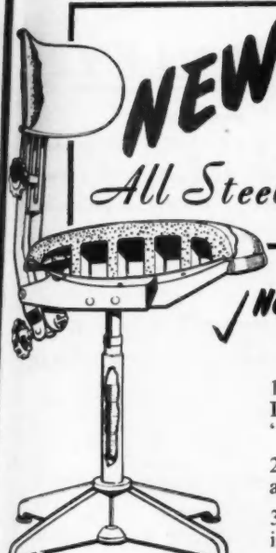

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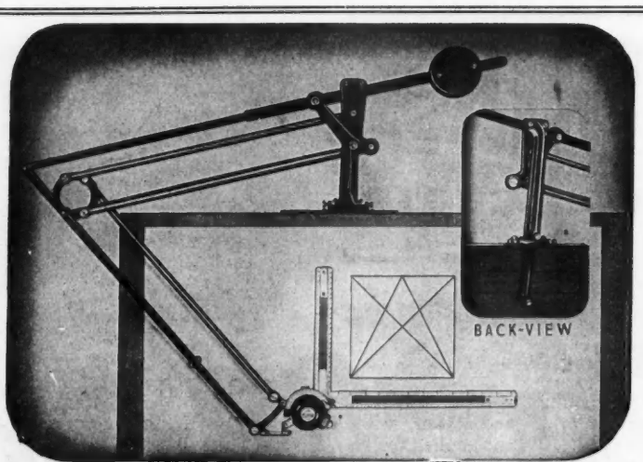

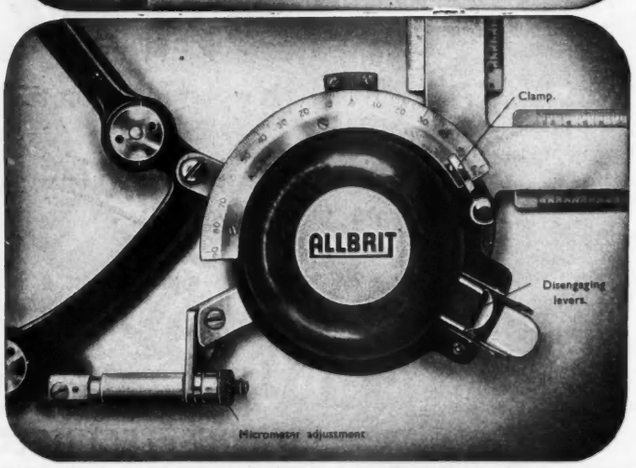

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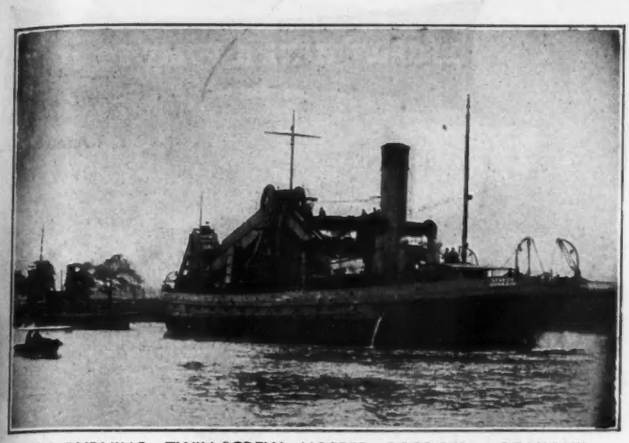

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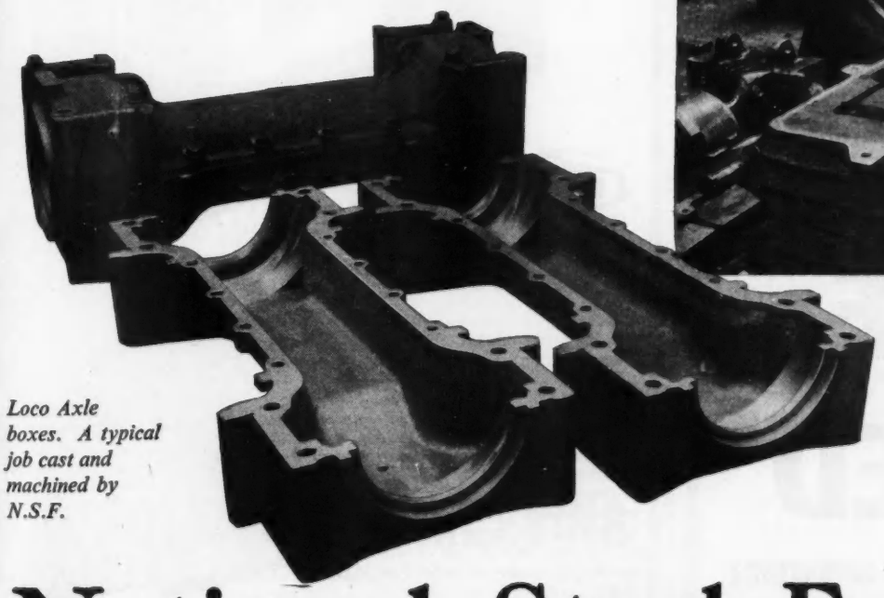

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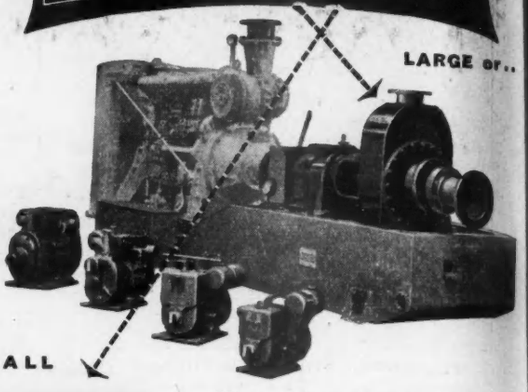

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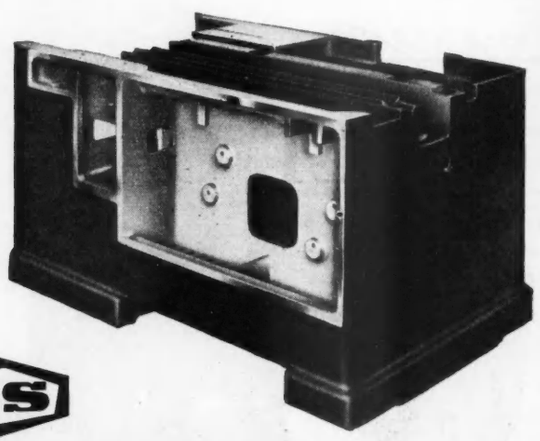

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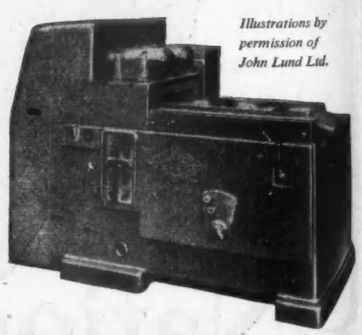

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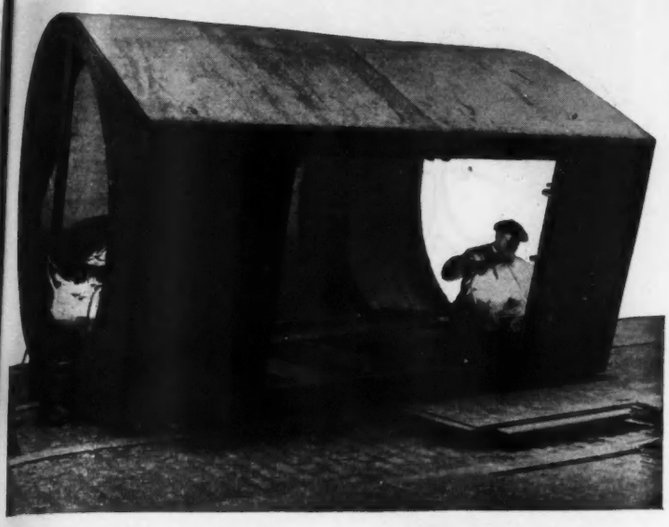

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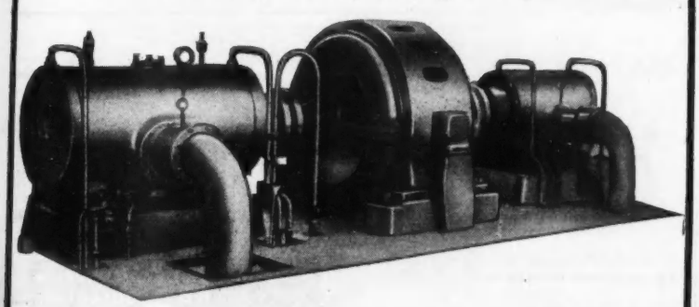

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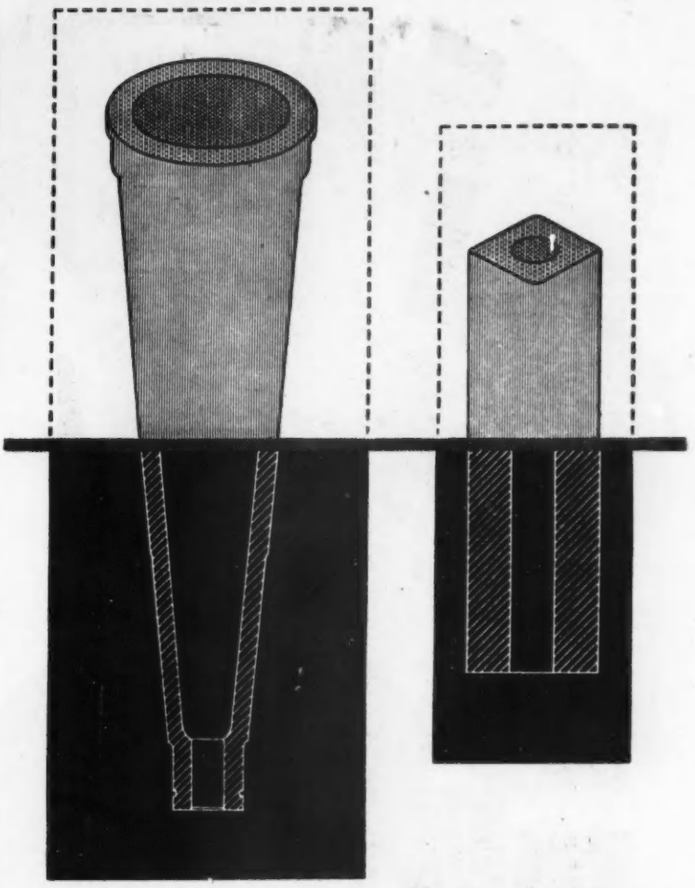

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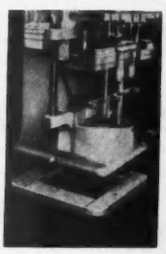

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B	103	1,690	Sp. G. x 2·5	7½	710	8	0	2,440	3	0	915
00	263	4,310	Sp. G. x 4	10	485	10	6	3,200	3	11	1,195
1	1,193	19,540	Sp. G. x 24	40	485	13	3	4,040	5	10	1,780
3A	4,315	70,680	Sp. G. x 100	100	485	20	0	6,097	11	0	3,353
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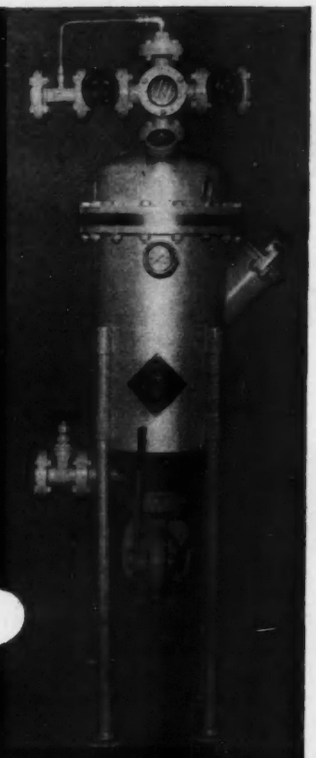

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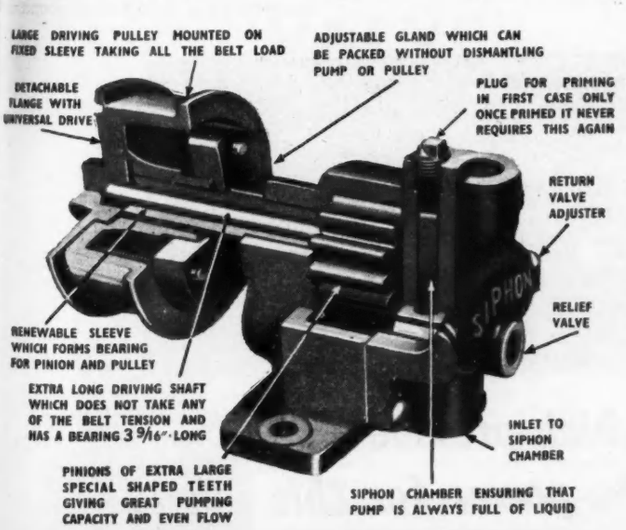
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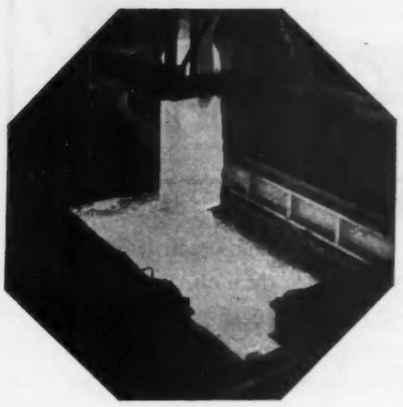
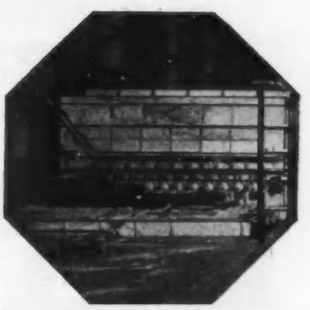


A soaking pit,

an annealing furnace,



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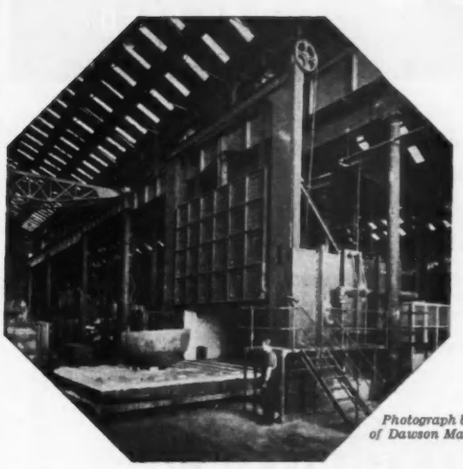

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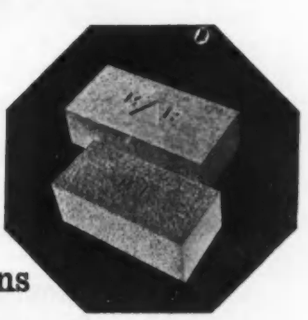
a forge furnace,

things about which it can pay handsomely to consult Morgans



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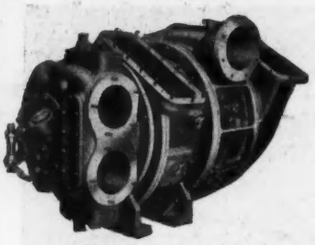
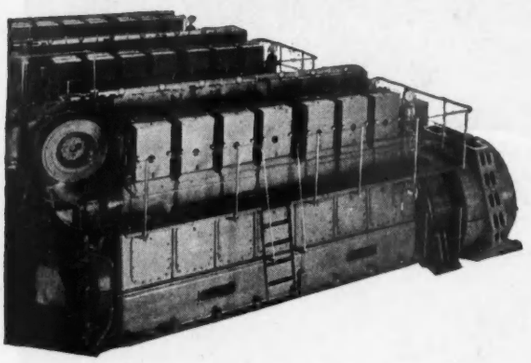


'English Electric' chose Napier Turbo-blowers

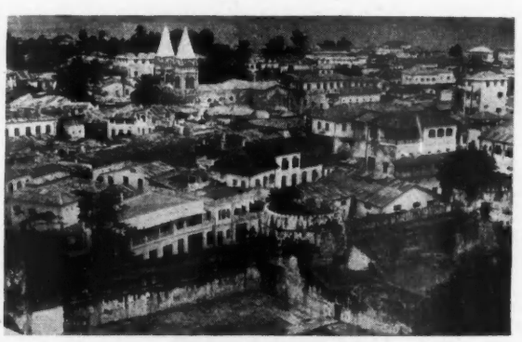


for these alternator sets

A Napier TS400 Turbo-blower is fitted to each of the three 'English Electric' 7SRL Diesel alternator sets installed in the Saateni Power Station, Zanzibar. These alternator sets provide the island's entire power supply. Why did 'English Electric' choose *Napier* blowers? Here are three good reasons:

- Napier blowers have *high adiabatic efficiency*, resulting in maximum power increase and low fuel consumption.
- Napier blowers are backed by a world-wide service and spares organisation.
- Napier's long experience in the design and manufacture of aircraft engines and gas turbine machinery guarantees a high standard of workmanship.

Napier Turbo-blowers are available in seven sizes for engines of 140-5,000 b.h.p. afloat and ashore. Multiple installations for engines of higher powers. On 4-stroke Diesels they can double the power, on 2-strokes they increase it by over 30%—often at a lower specific fuel consumption. Napier Turbo-blowers are currently in service in 69 countries.



which provide the power for this island

NAPIER Turbo-blowers

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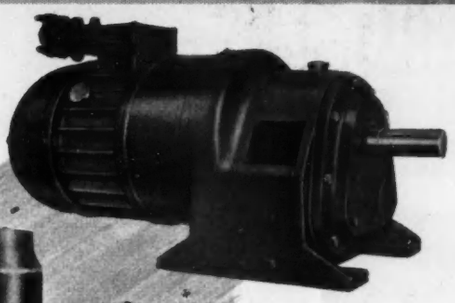
Buxton certified for groups 1, 2 and 3 gases.

Motors complying with BS. specifications.



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VALVE RESEATER
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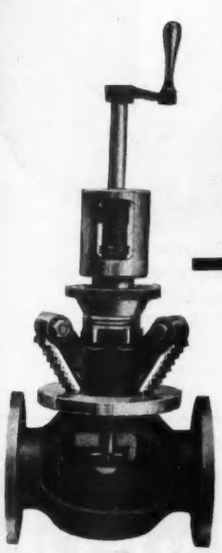

This tool not only saves steam—and therefore fuel—but saves TIME and dislocation of work as the valve can be reseated WITHOUT BREAKING THE PIPELINE. It takes only one man to operate it and it gives a true face free from knurling in a few minutes. It is self-centring in the valve chest and the cutter is visible during the reseating operation. Moderate in price—write for full descriptive literature.

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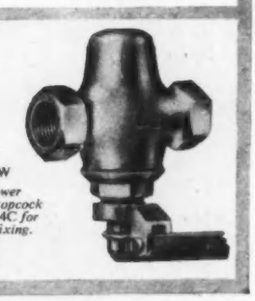

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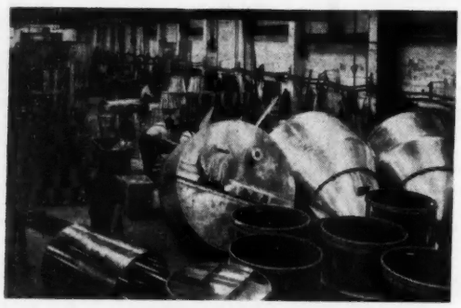

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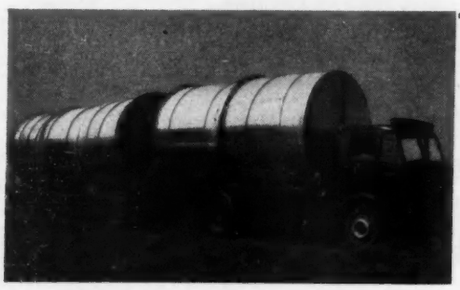

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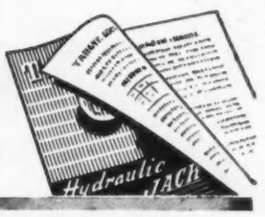

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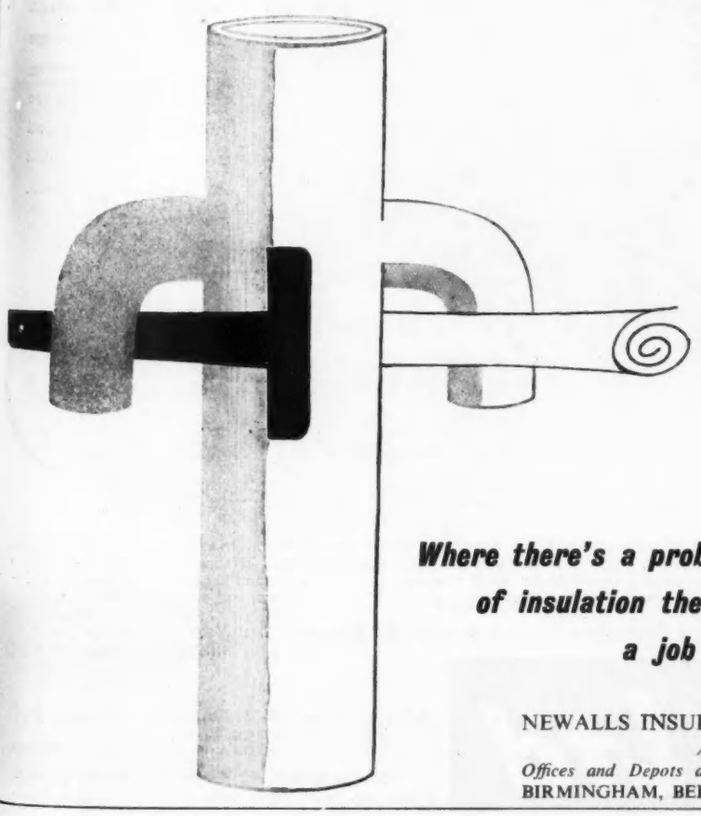

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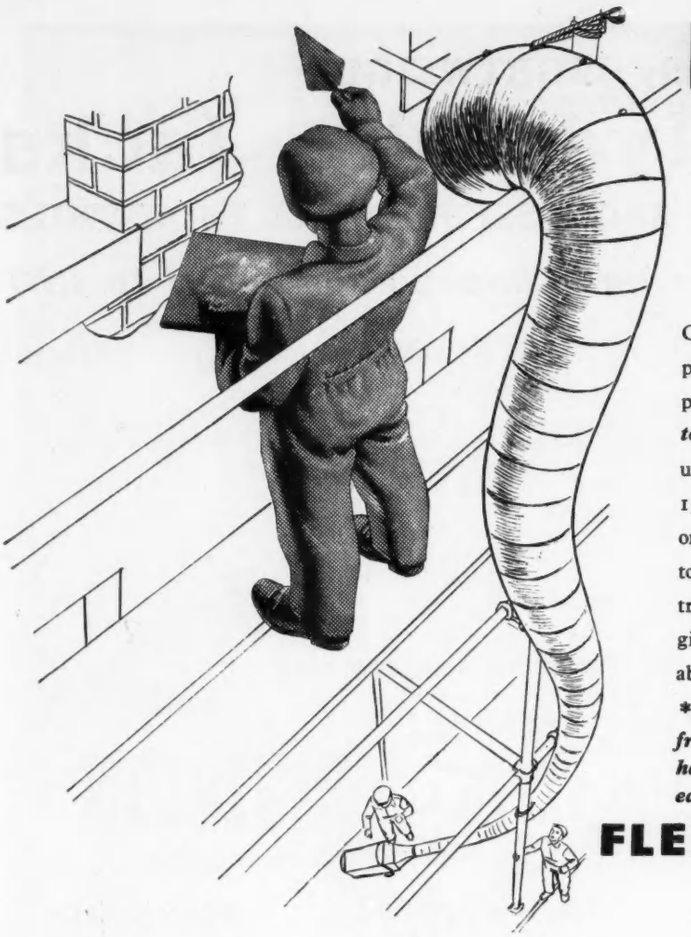

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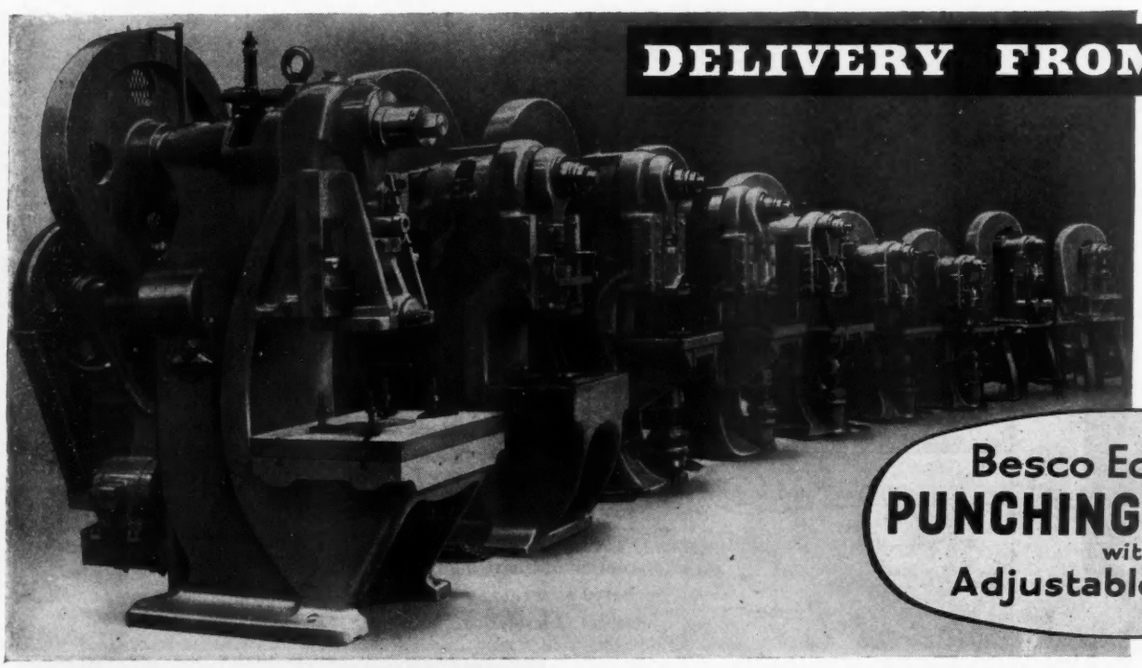

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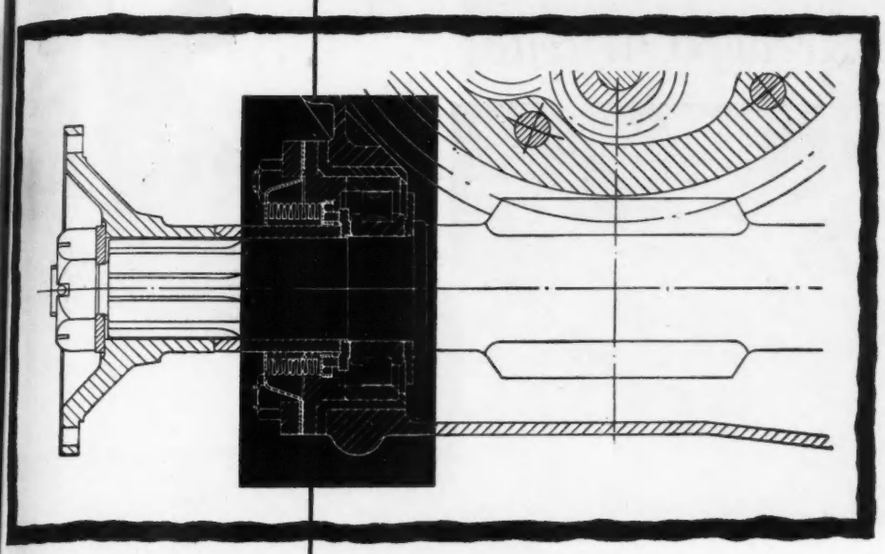

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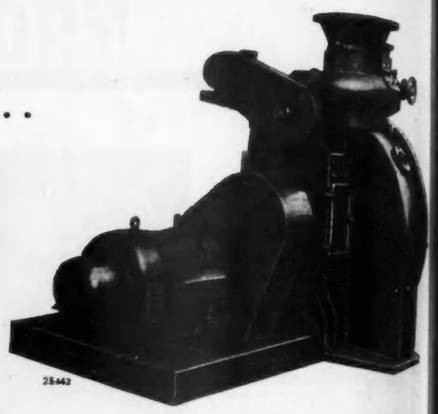

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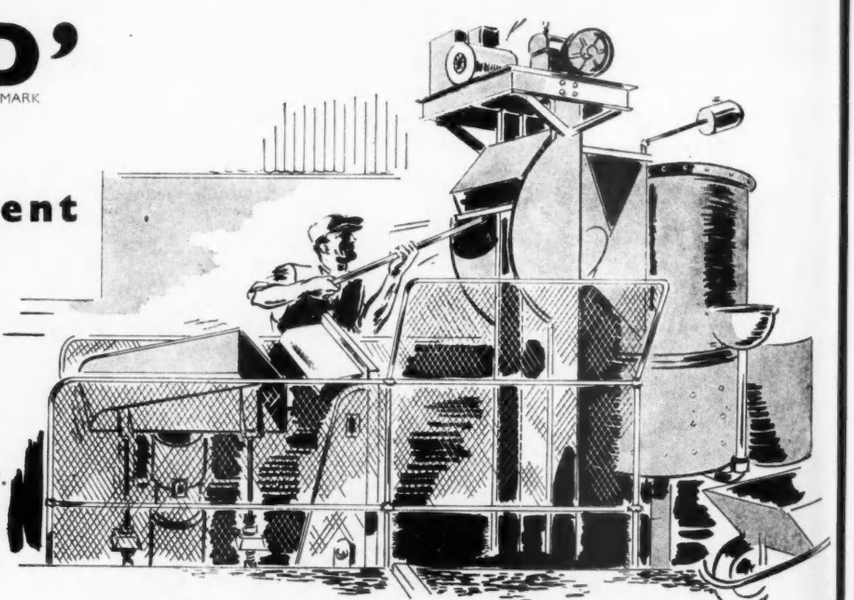

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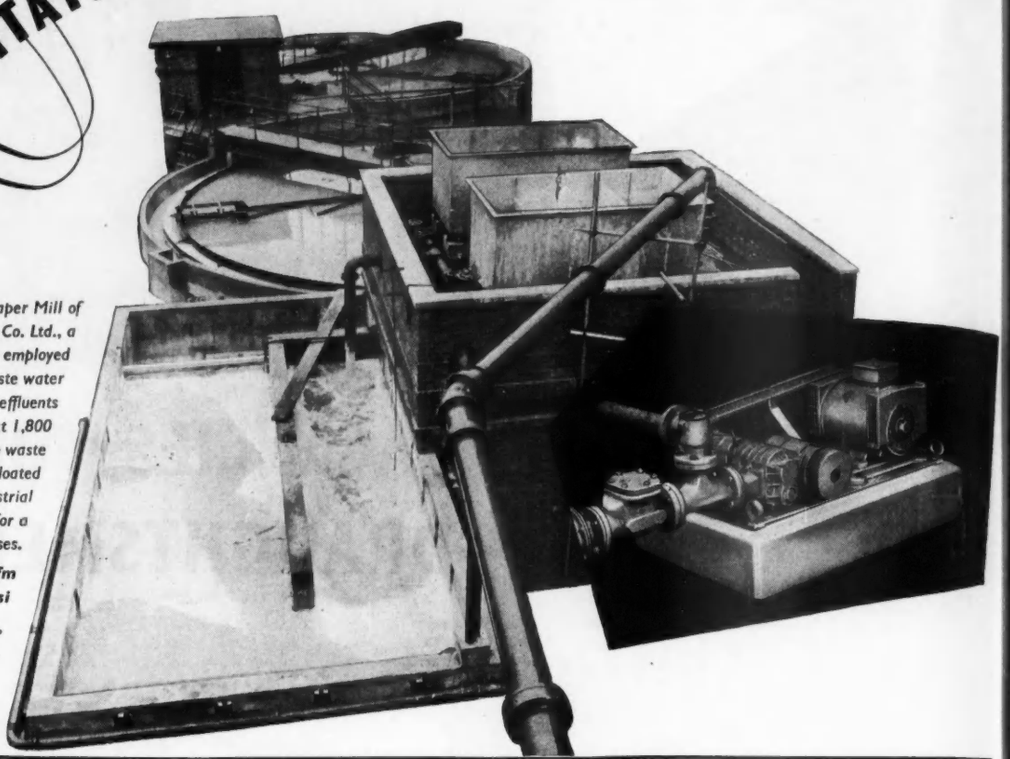

In the Aylesford Paper Mill of Messrs. Albert E. Reed & Co. Ltd., a Godfrey Model K 200 industrial blower is employed to recover fibrous material from waste water by flotation and to mix thoroughly different kinds of effluents prior to sedimentation. The blower, driven at 1,800 r.p.m., supplies 50 c.f.m. of oil free air to agitate waste water in a tank ; fibrous material is thereby floated to the surface and then removed. Godfrey industrial blowers are widely used in industry for a variety of processes.

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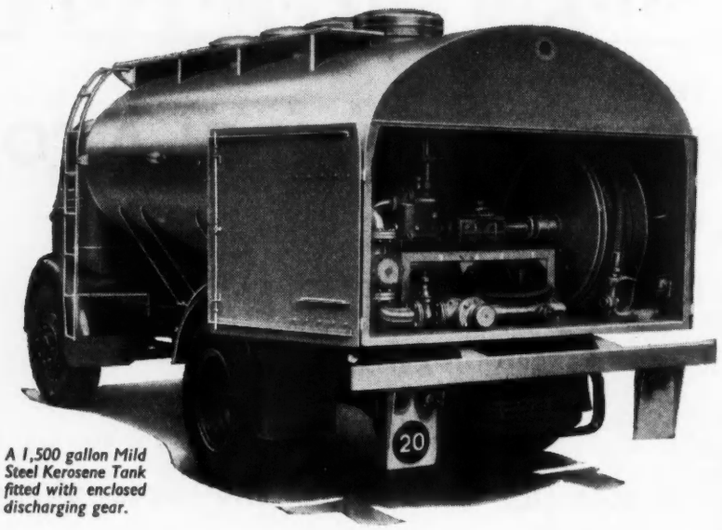

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for the transport of liquid in bulk

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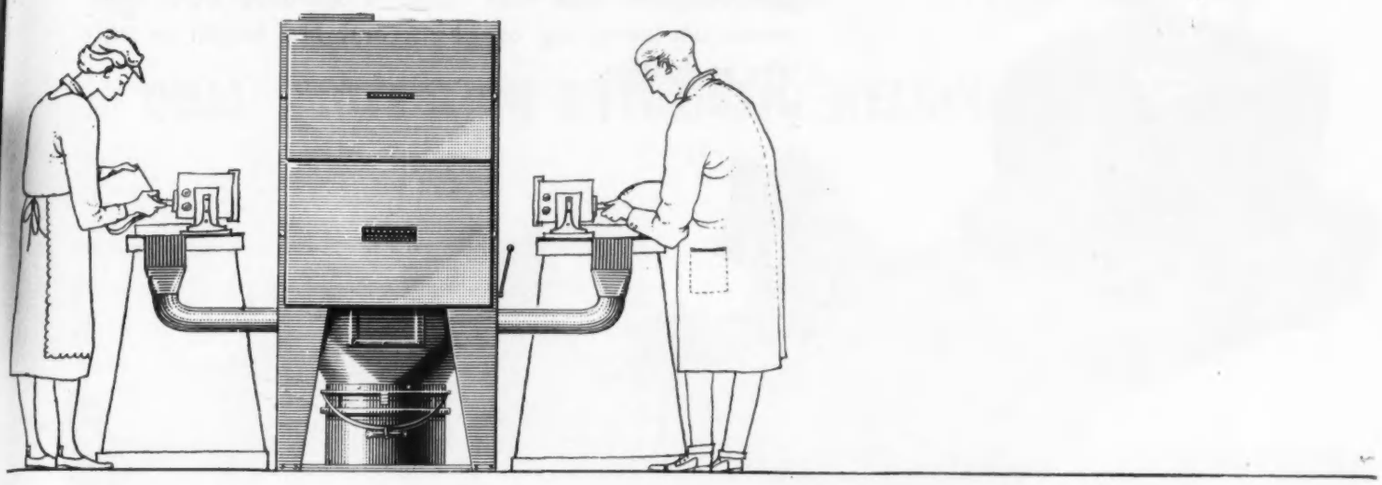

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see us for dust

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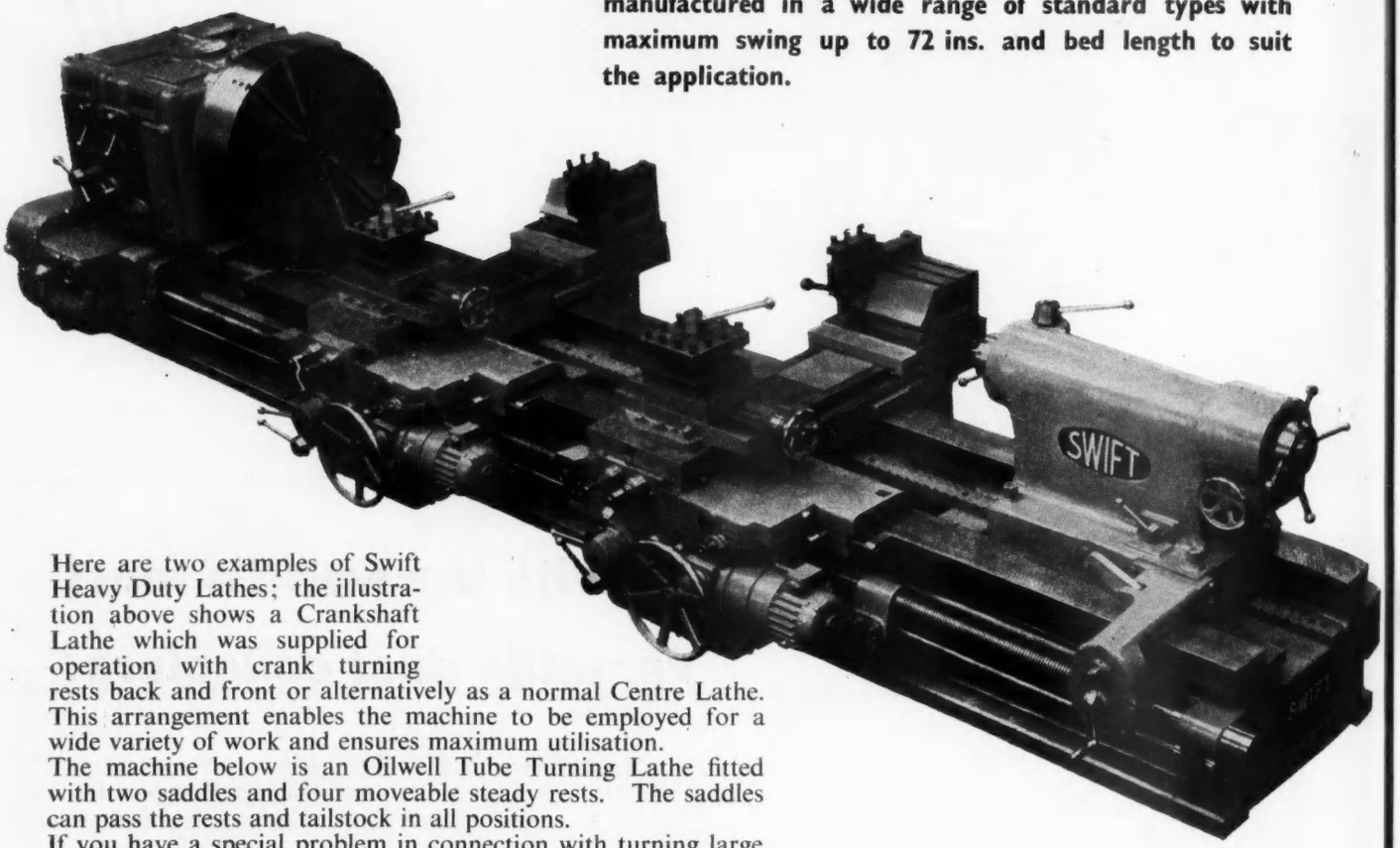
manufactured in a wide range of standard types with maximum swing up to 72 ins. and bed length to suit the application.

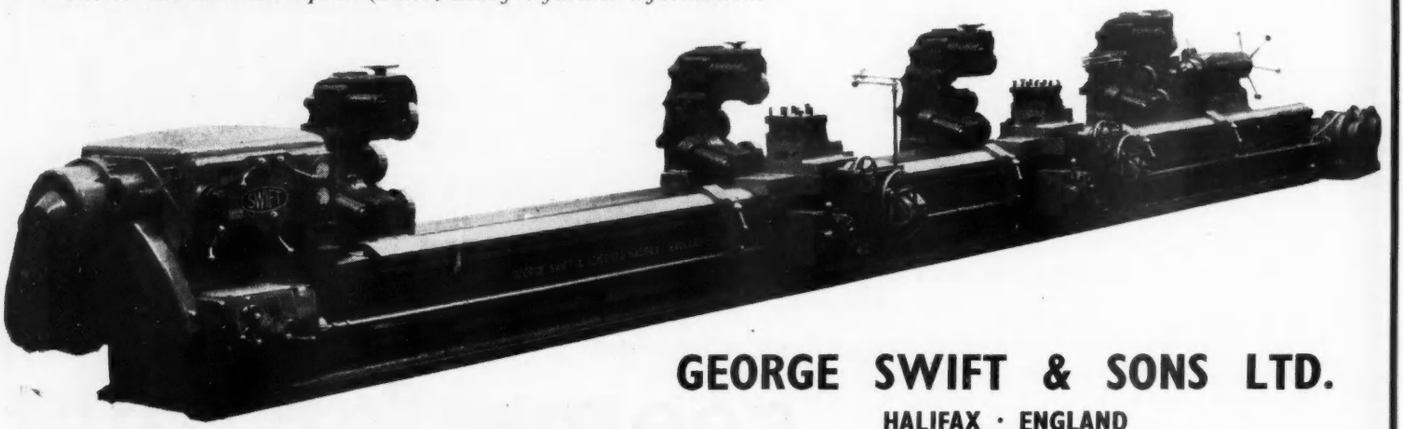


Here are two examples of Swift Heavy Duty Lathes; the illustration above shows a Crankshaft Lathe which was supplied for operation with crank turning rests back and front or alternatively as a normal Centre Lathe. This arrangement enables the machine to be employed for a wide variety of work and ensures maximum utilisation.

The machine below is an Oilwell Tube Turning Lathe fitted with two saddles and four moveable steady rests. The saddles can pass the rests and tailstock in all positions.

If you have a special problem in connection with turning large workpieces or simply require a standard Centre Lathe, a modern Swift Lathe can probably meet your requirements.

Write to Drummond-Asquith (Sales) Ltd. for further information.



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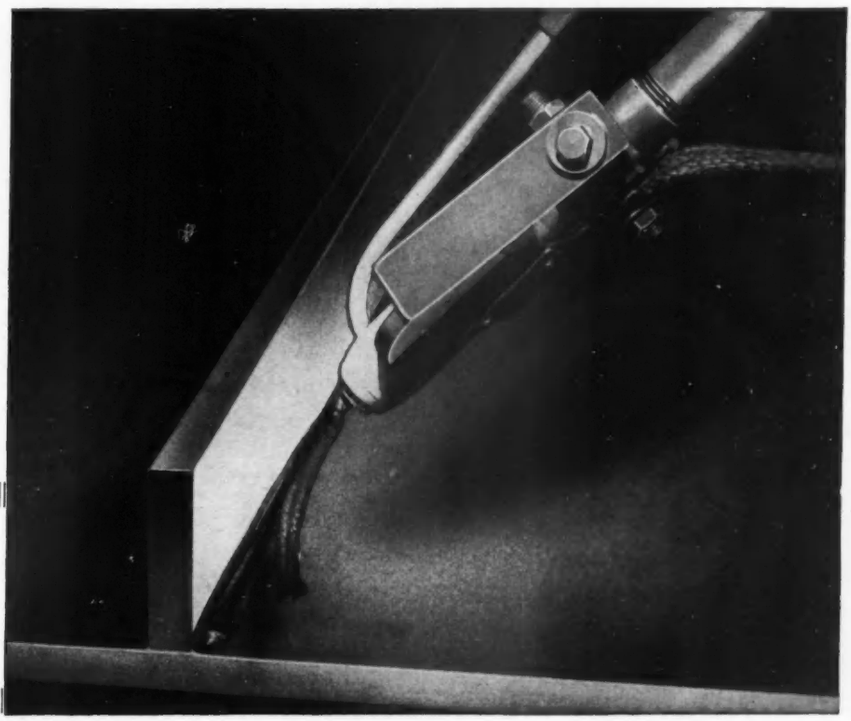

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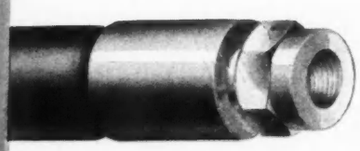
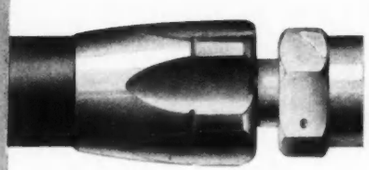


Low/Medium pressure hose suitable for oil, fuel, water, air, refrigerants, etc. in sizes from $\frac{1}{8}$ in. to 2 in. and pressures to 75 p.s.i.

TYPE 10

Two-wire braid super high pressure hose with a pressure range up to 5,000 p.s.i. This hose is especially suitable for H.P. hydraulic systems.

TYPE 8



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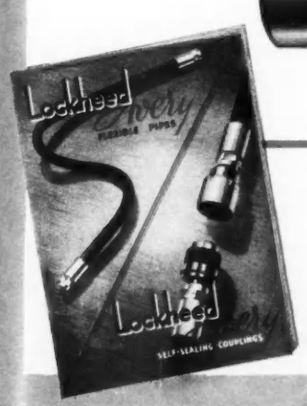

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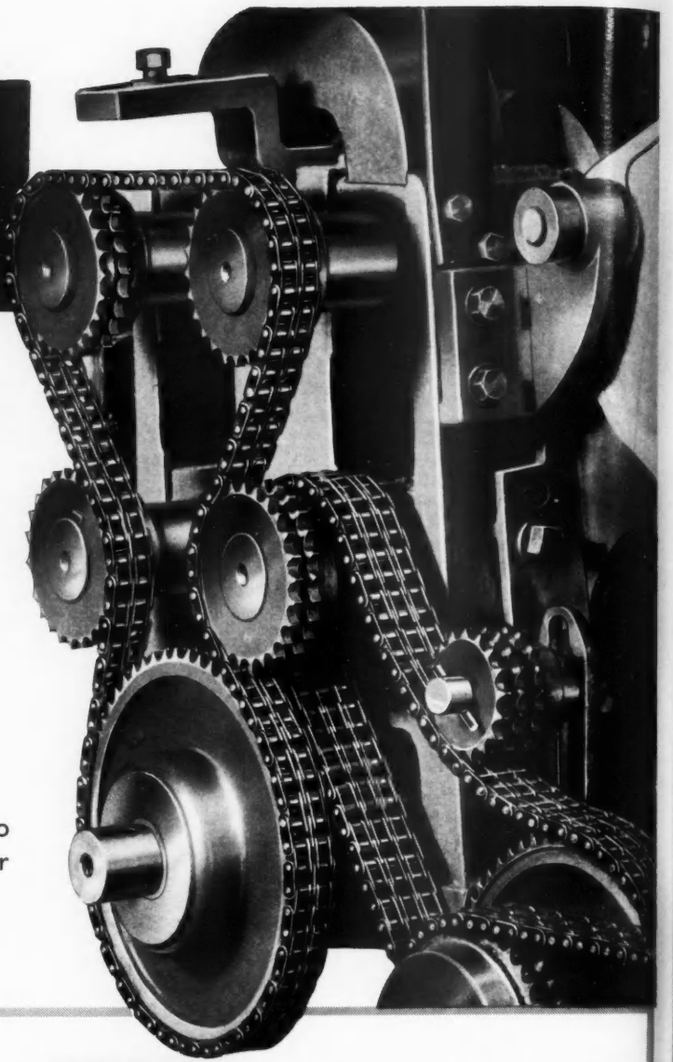

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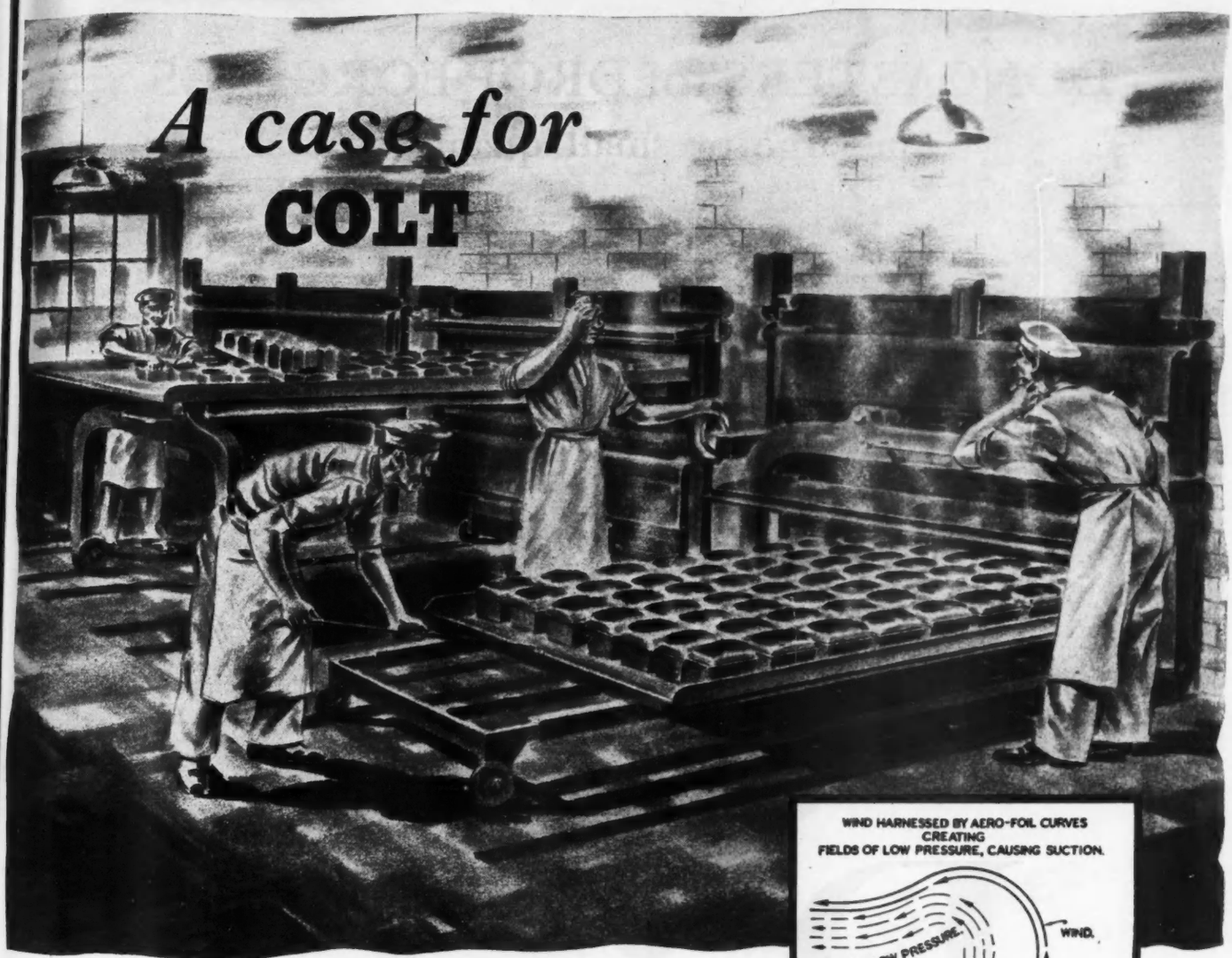

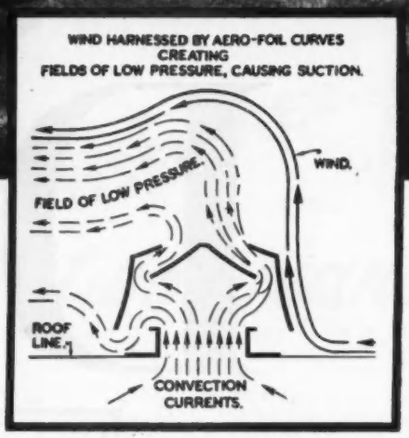
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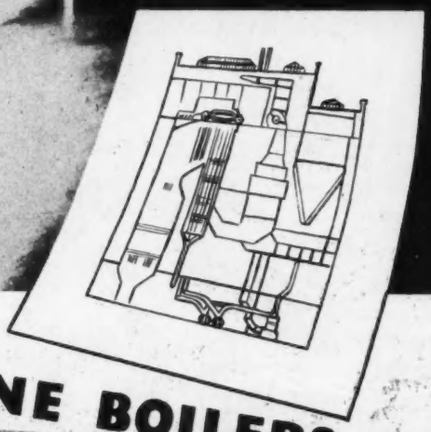

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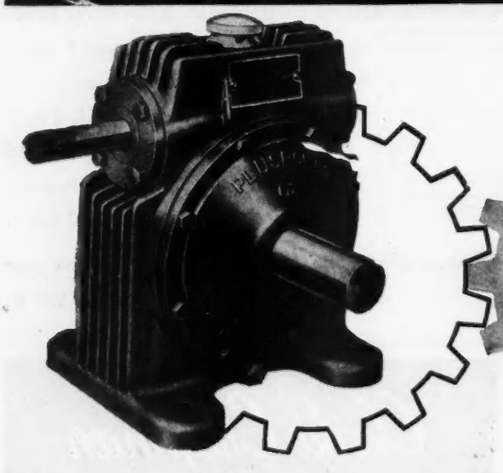

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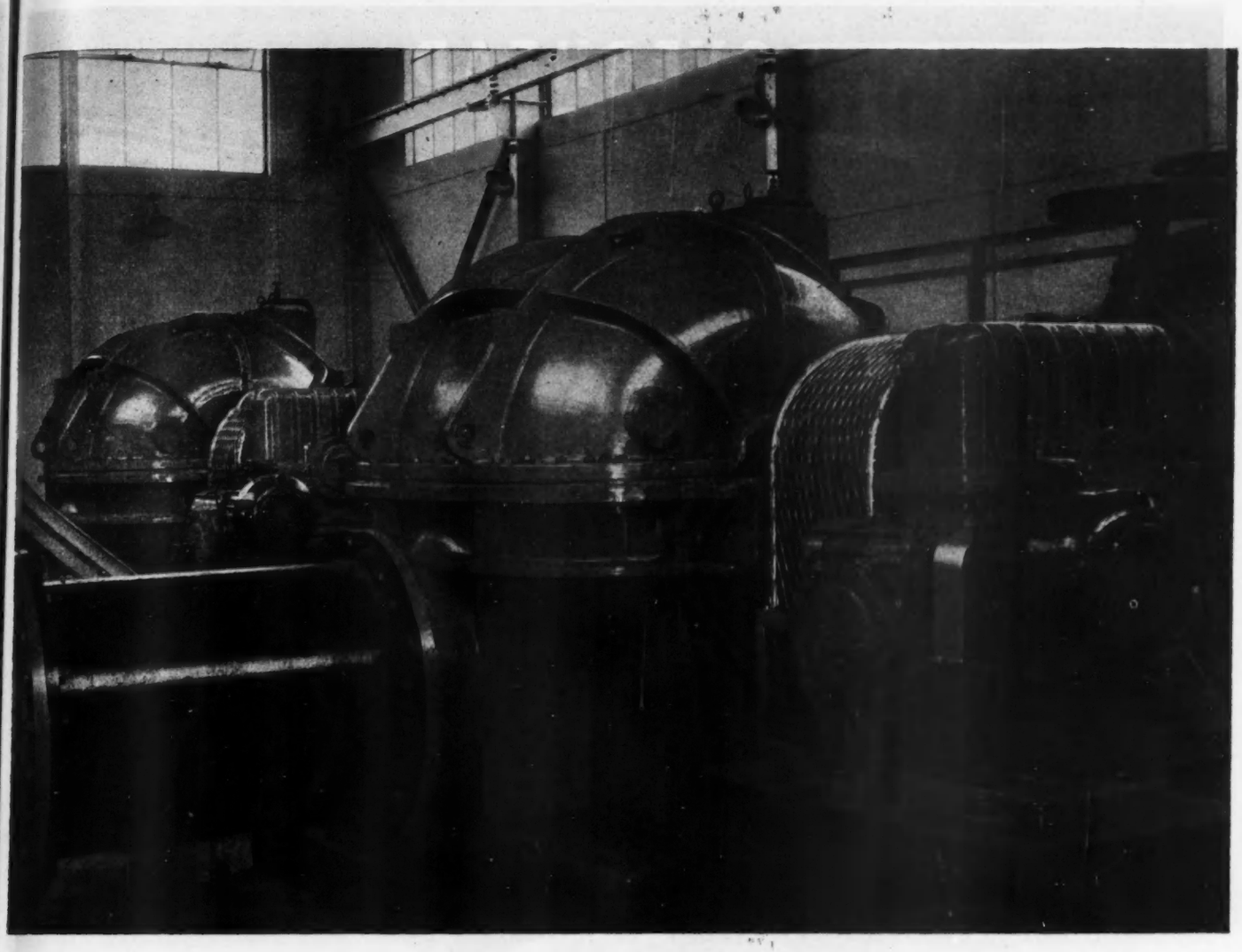

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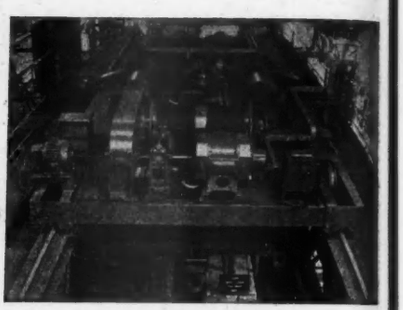
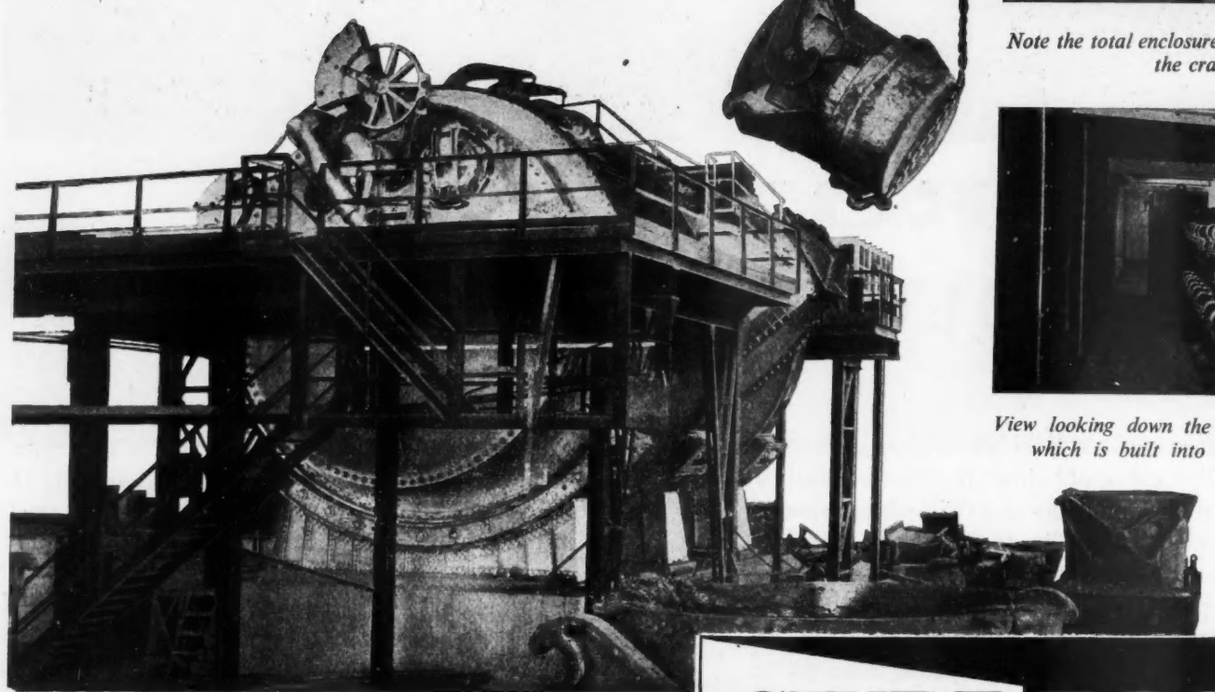


Note the total enclosure of all gearing on the crab.

View looking down the contactor house which is built into the girders.



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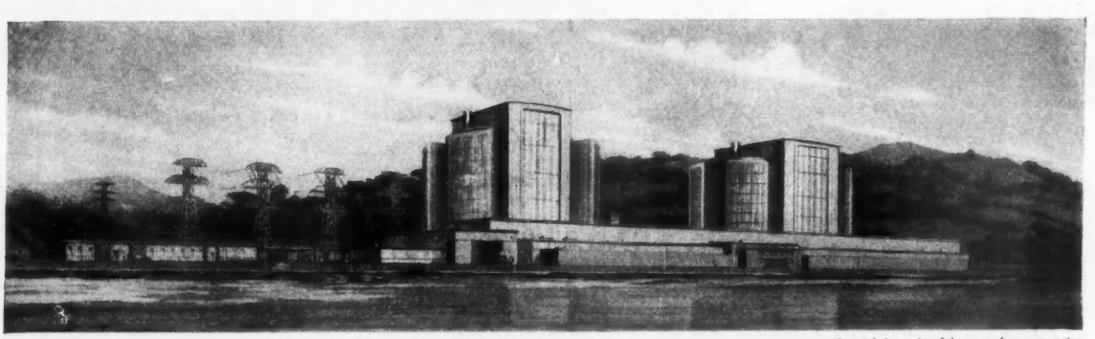

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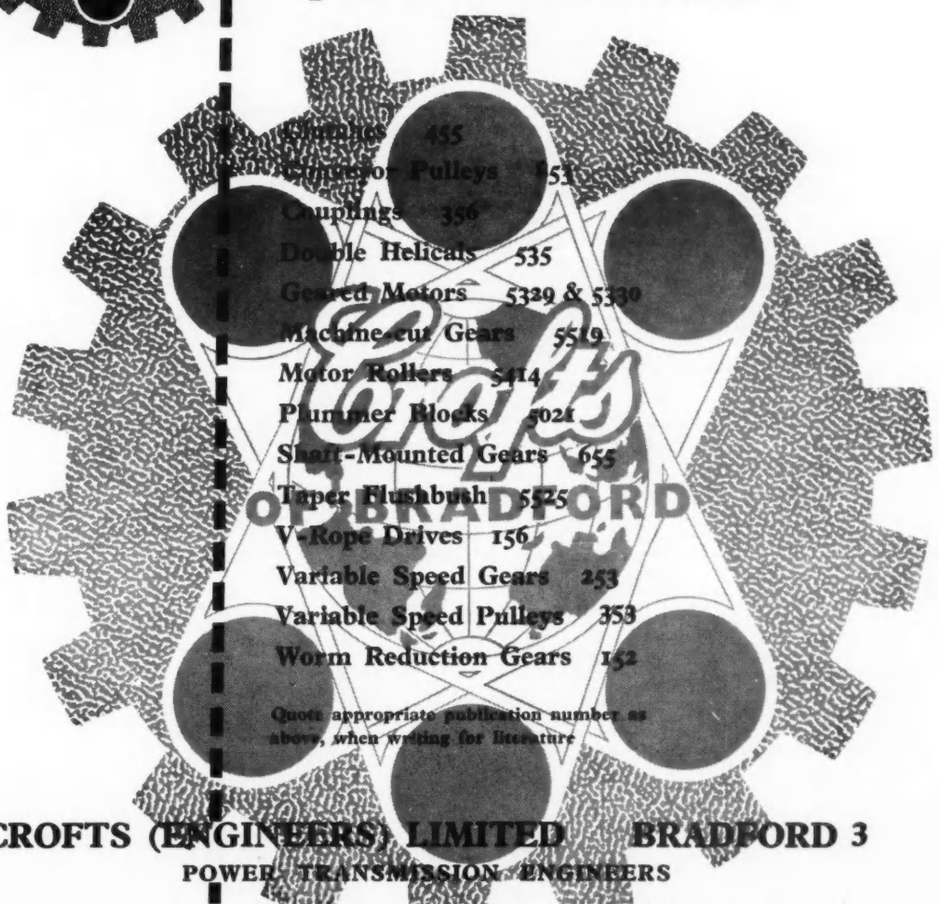

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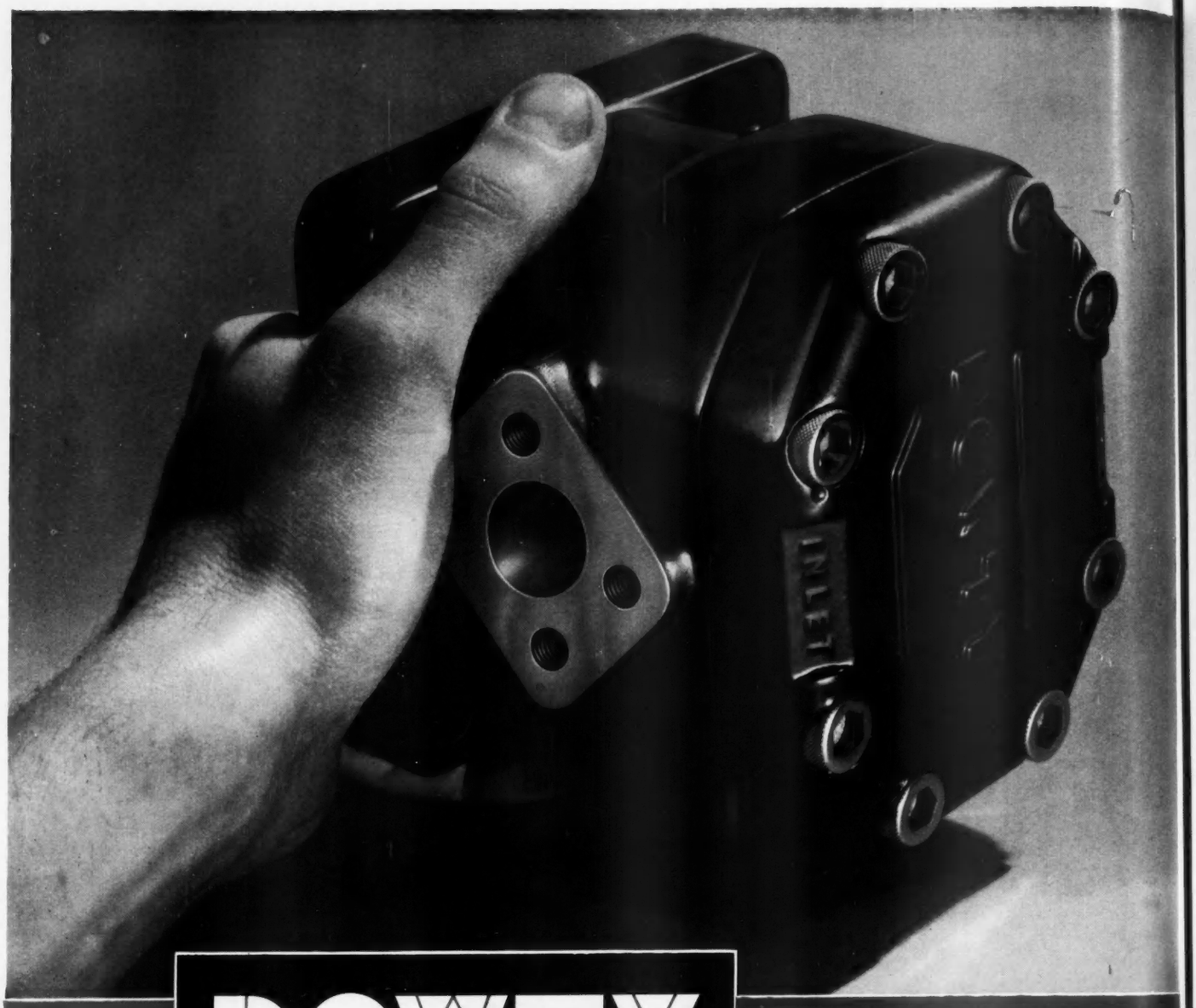

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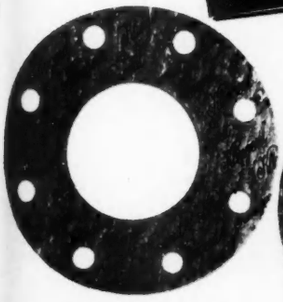

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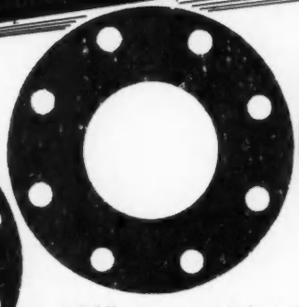

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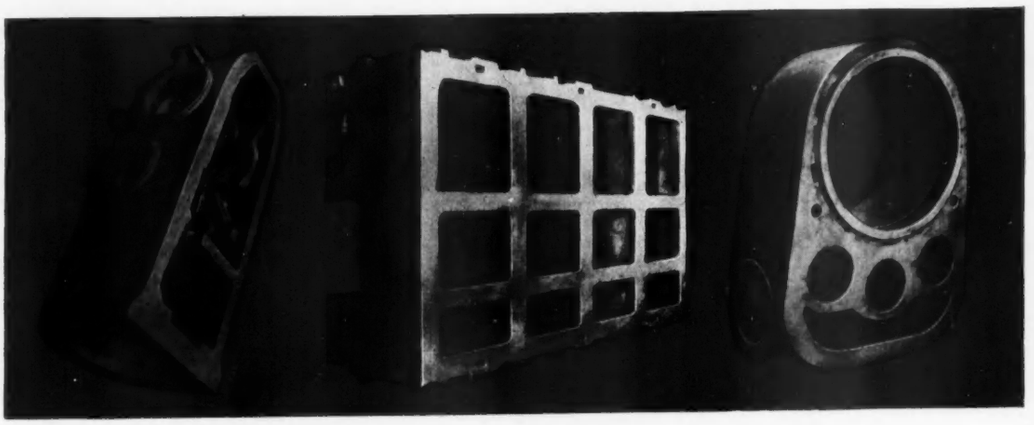
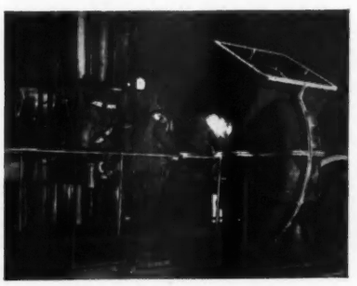
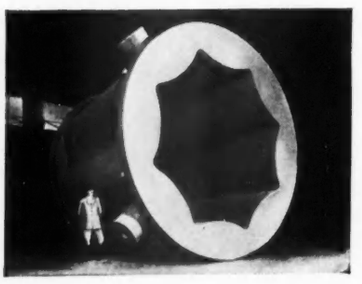


DISTINGTON ENGINEERING COMPANY LIMITED
WORKINGTON CUMBERLAND ENGLAND

120 TONS





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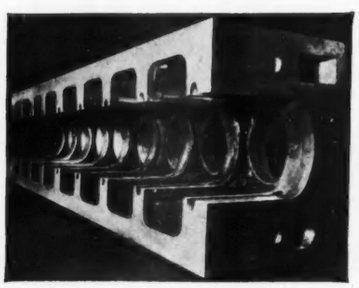

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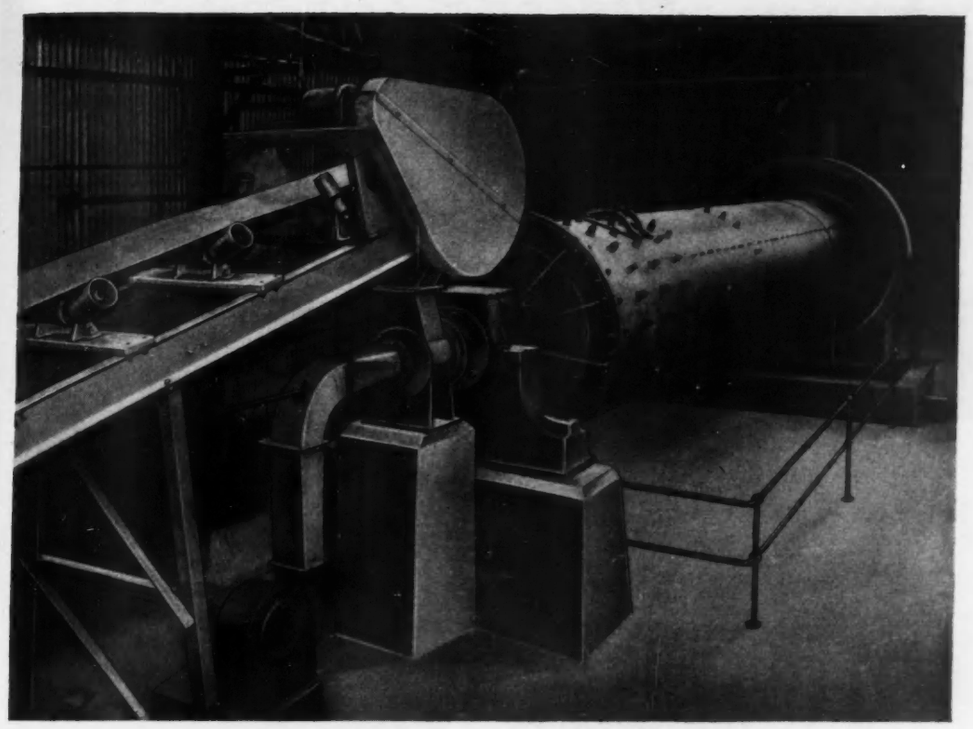

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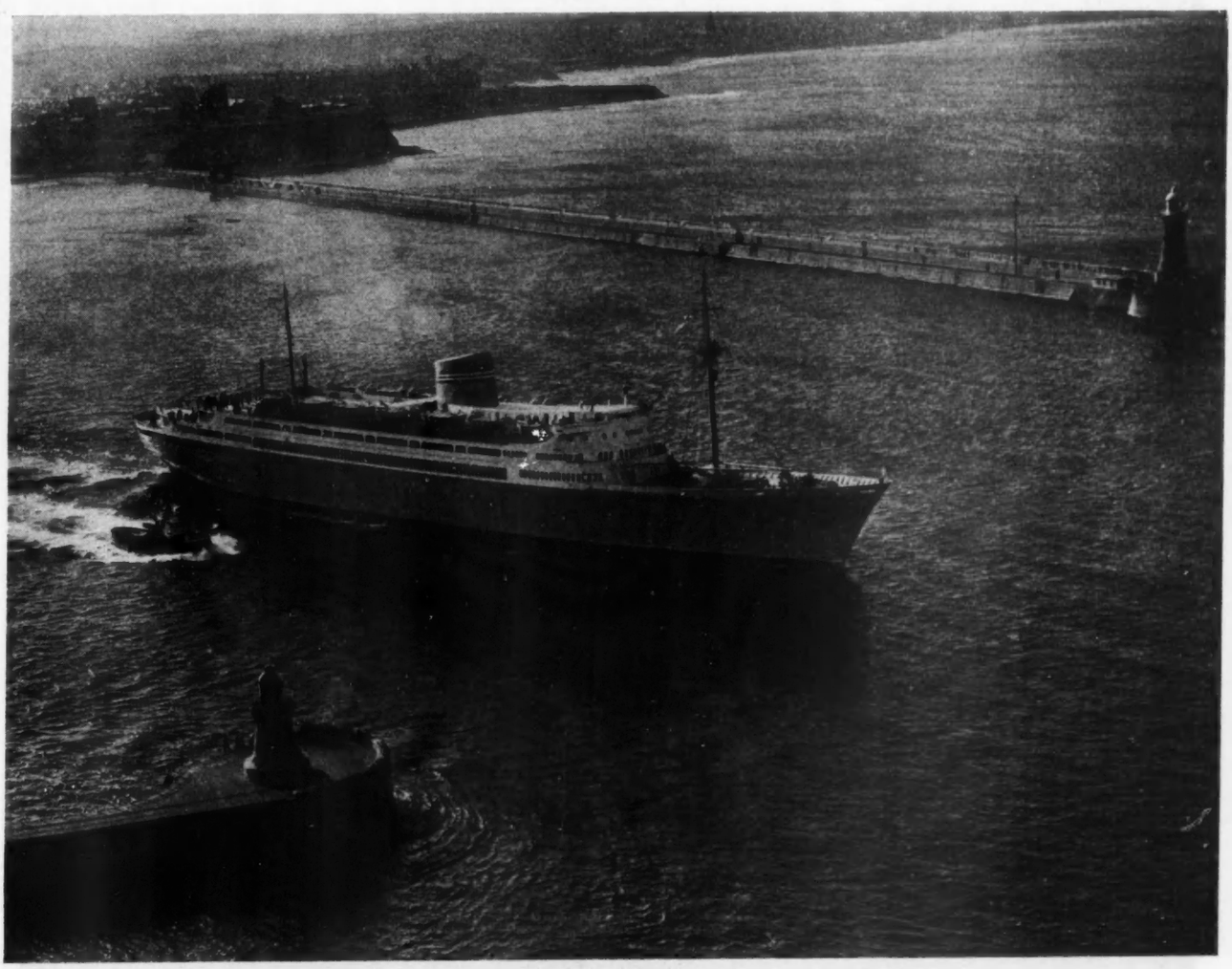
The motor ship "Bergensfjord" built by Swan Hunter and Wigham Richardson Limited for Den Norske Amerikalinje A/S of Oslo has a gross weight of 18,750 tons. Considerable quantities of Appleby-Frodingham plates and sections were supplied to the builders of this ship.

Photograph reproduced by courtesy of Swan Hunter and Wigham Richardson Limited.



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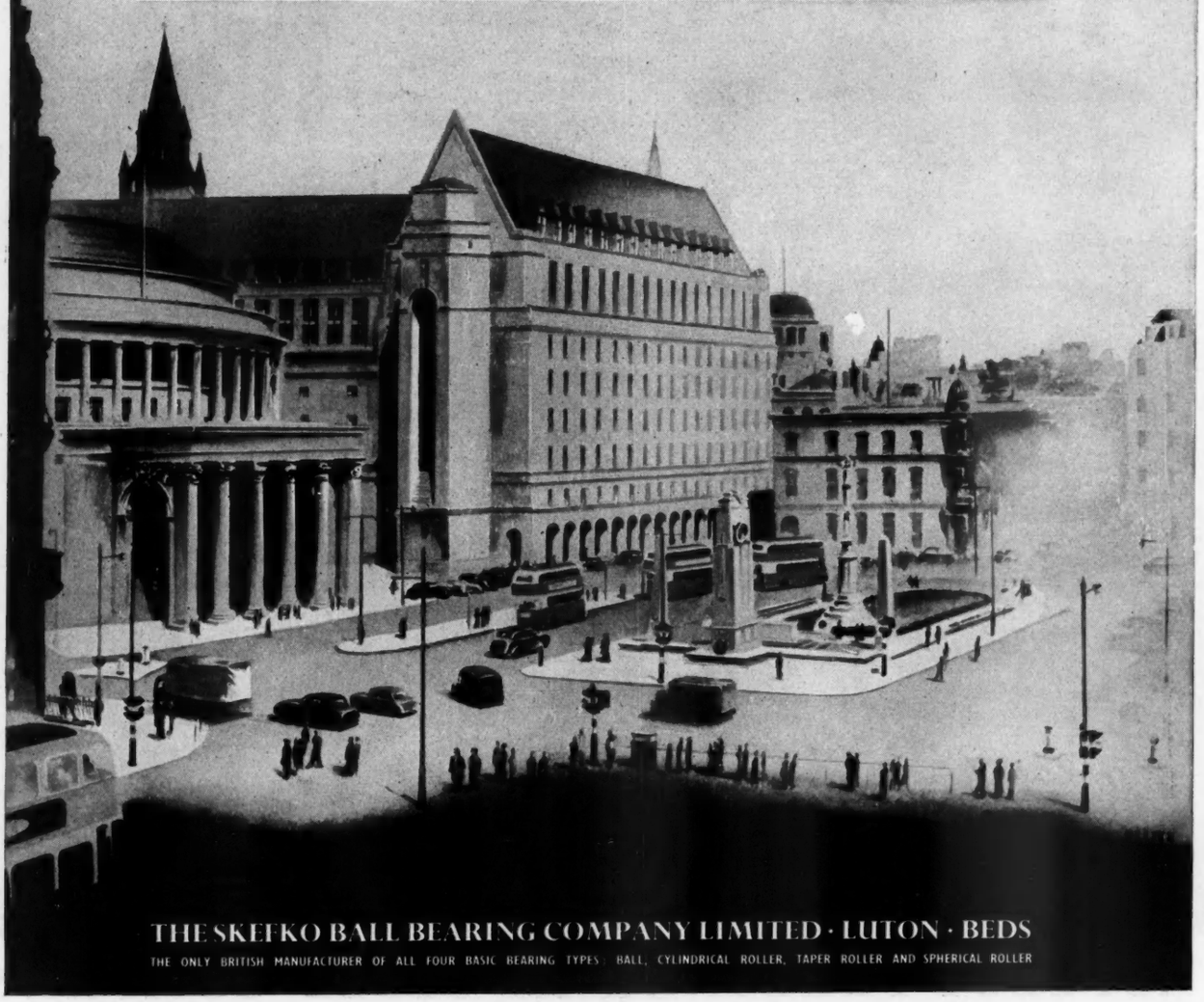

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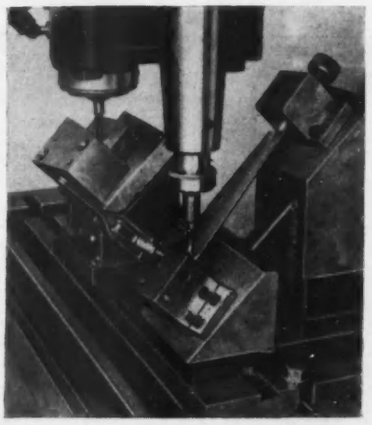
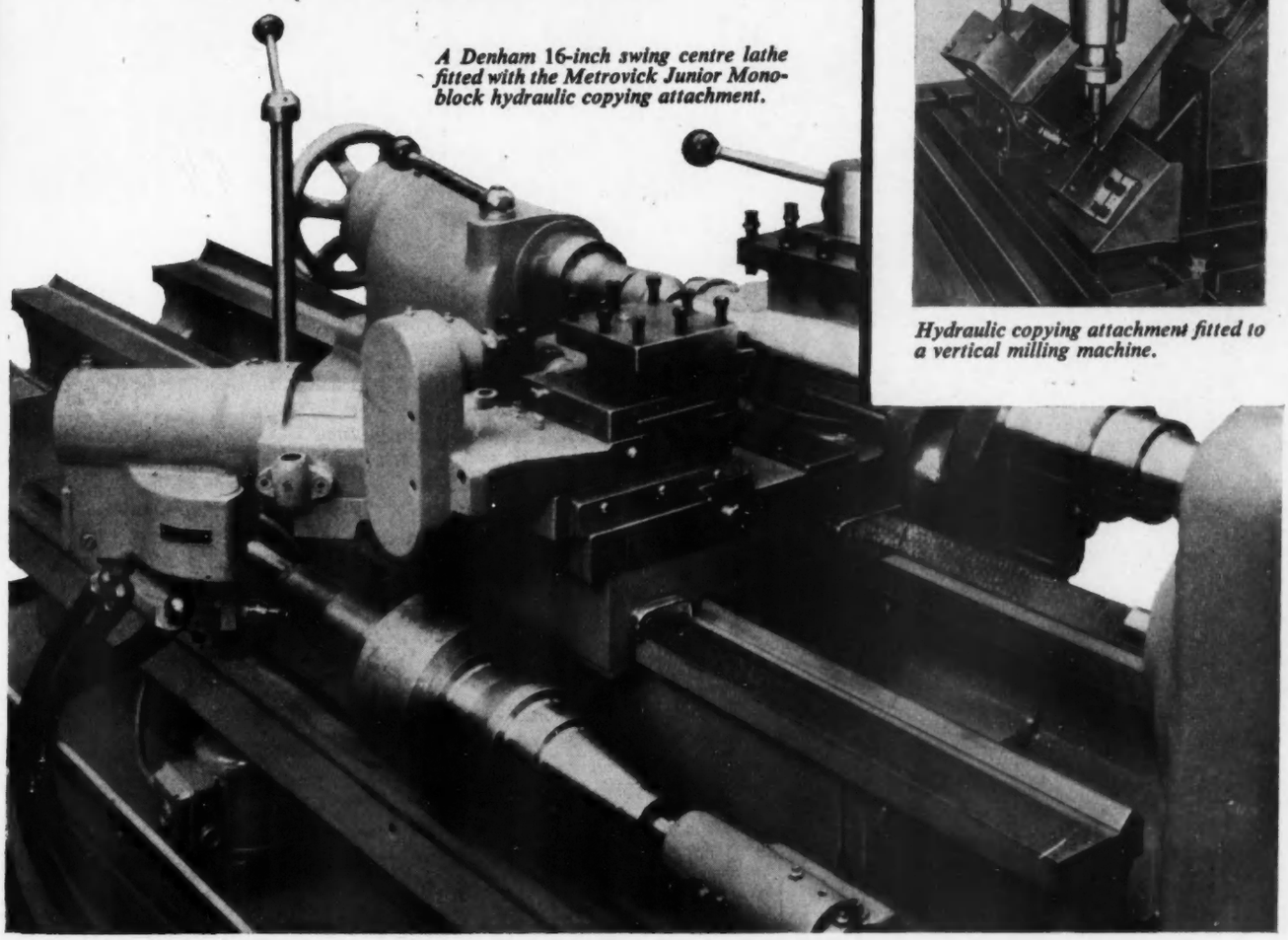
Metrovick hydraulic contouring attachment fitted to a Richards 6-ft. Double Standard Vertical Boring and Turning Mill.



Hydraulic copying attachment fitted to a vertical milling machine.

A Denham 16-inch swing centre lathe fitted with the Metrovick Junior Monoblock hydraulic copying attachment.



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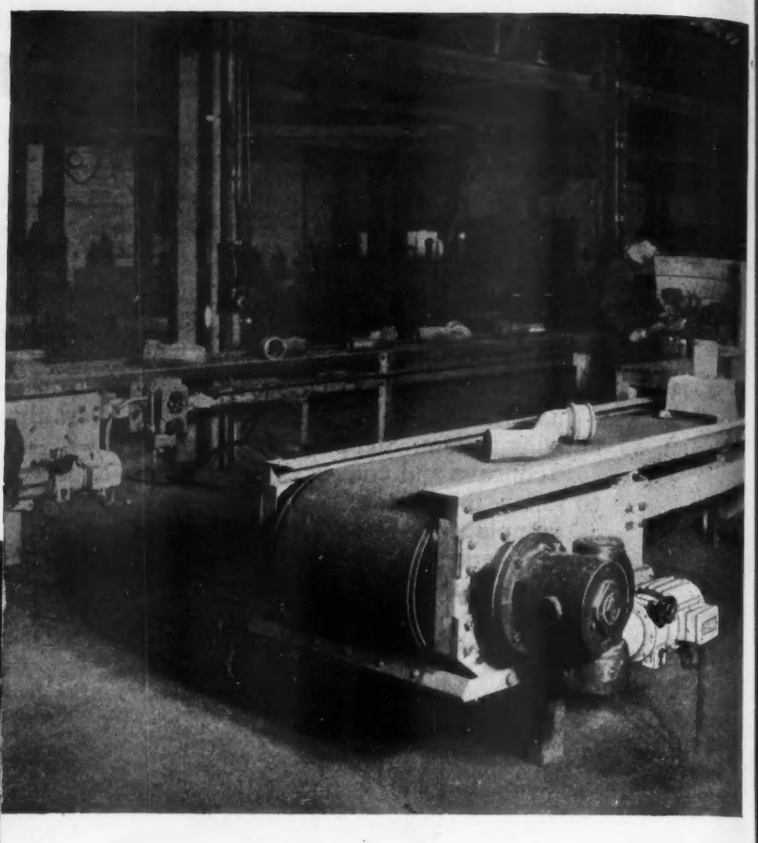

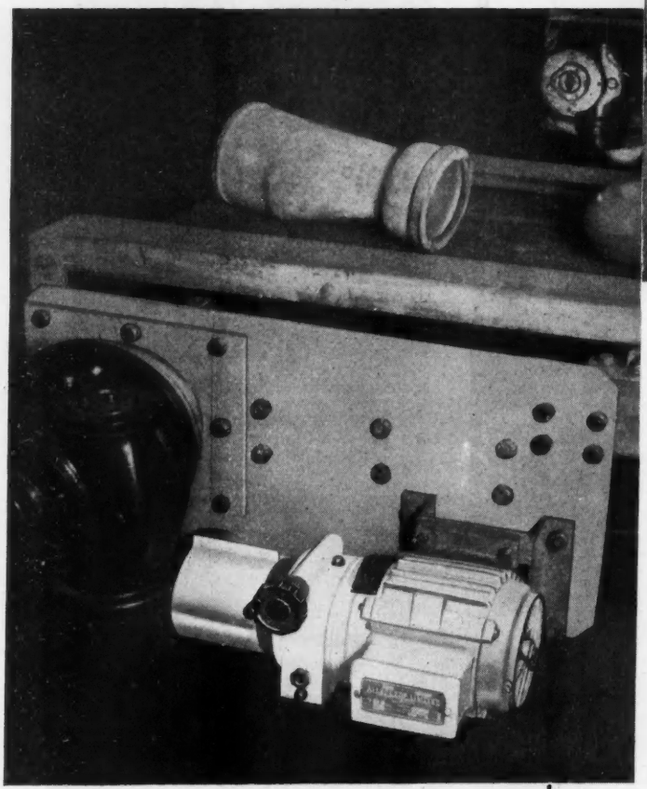

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- Finger tip control giving *STEPLESS SPEED VARIATION* between 1/3 and 3 times the input speed.
- Supplied with free shaft ends or direct coupled motor.
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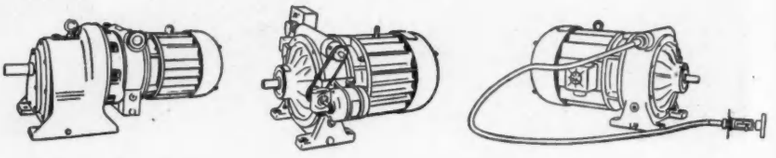

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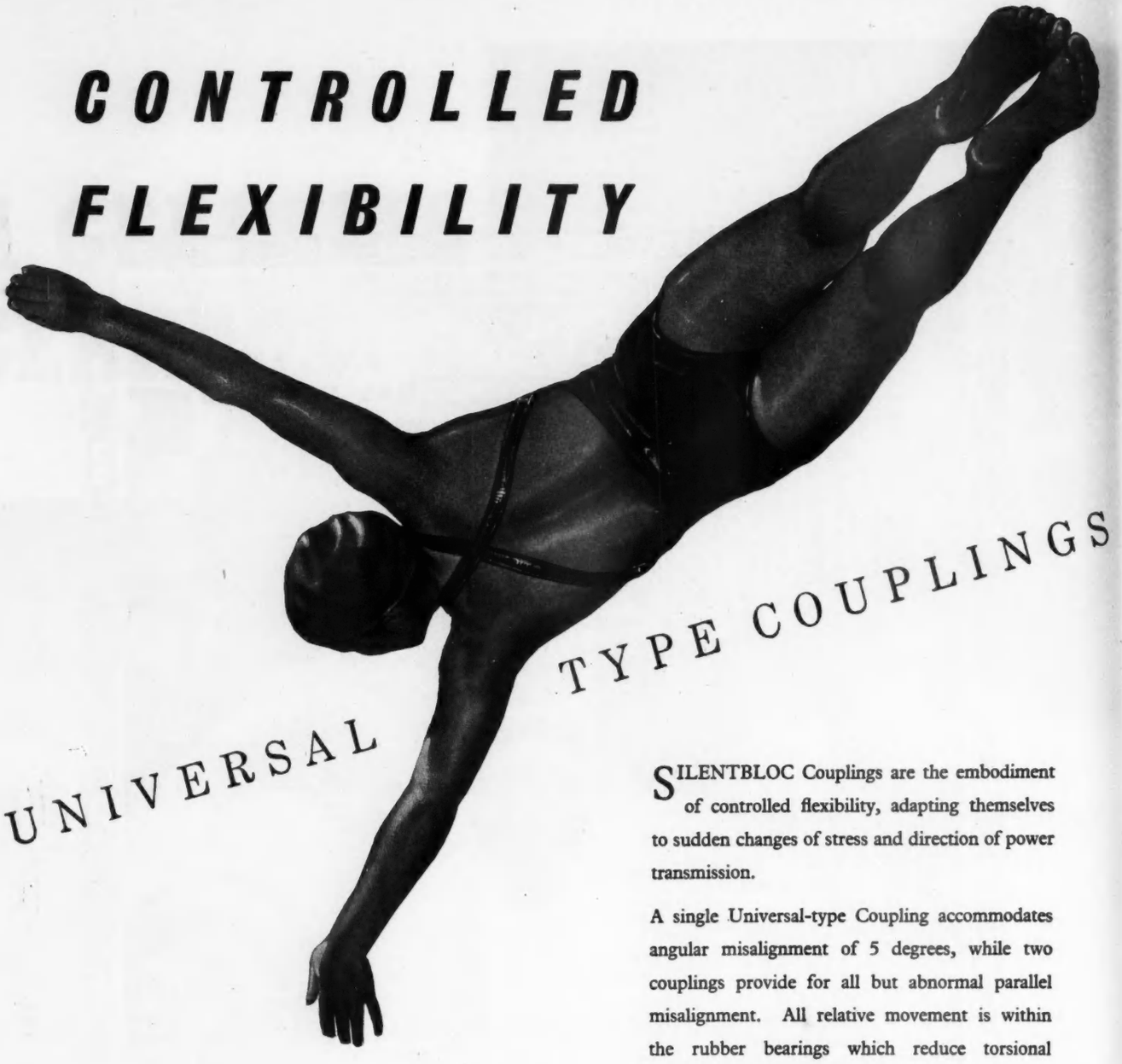

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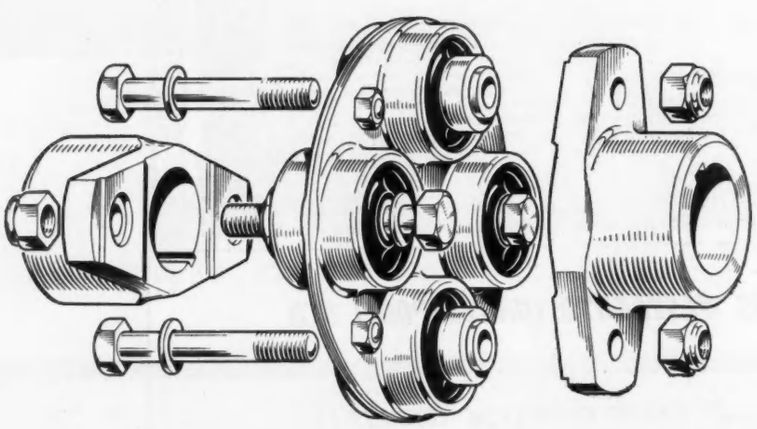

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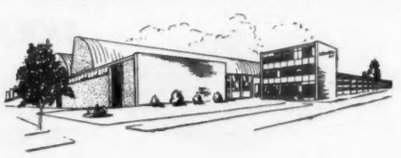

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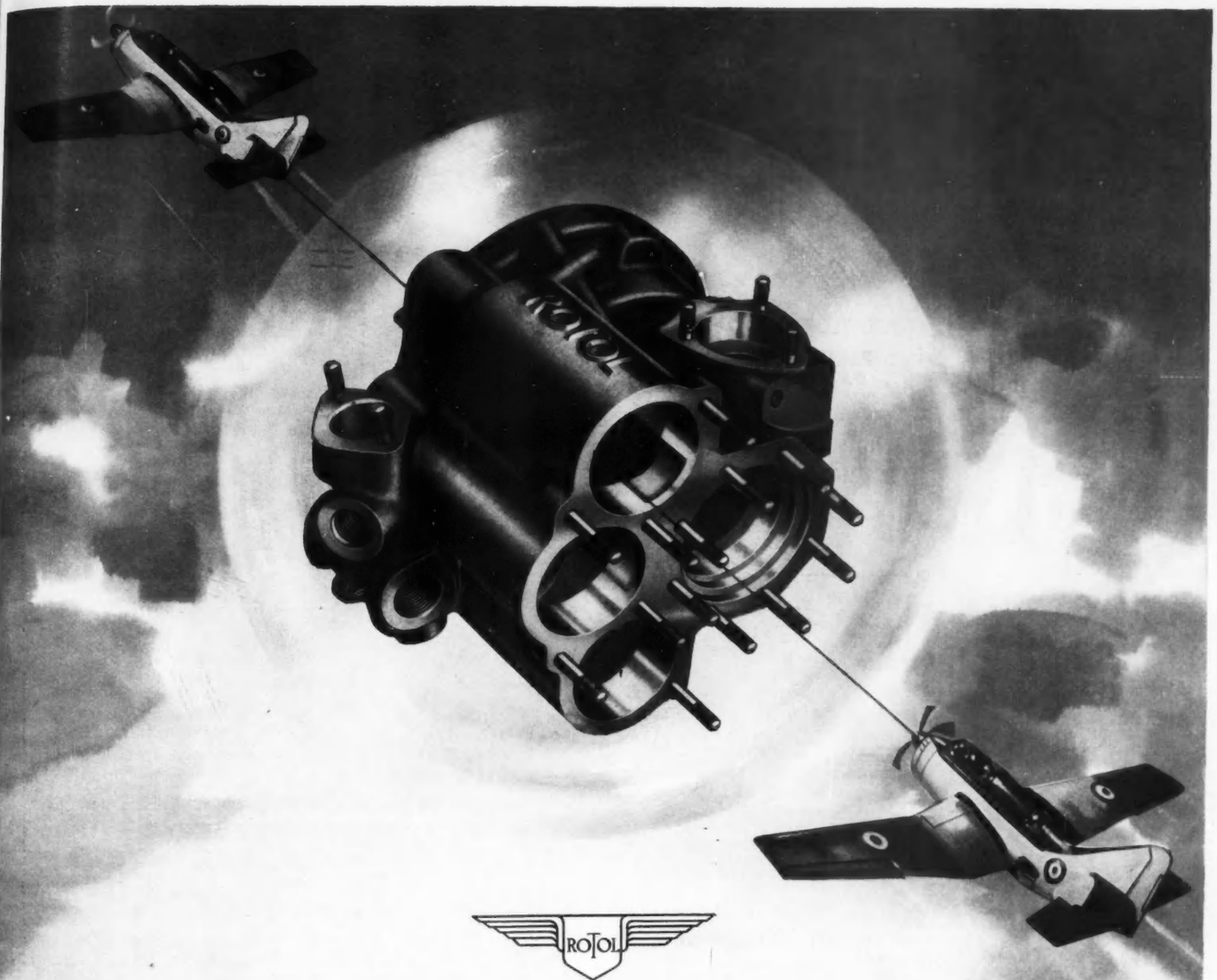

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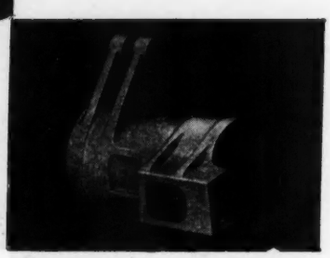

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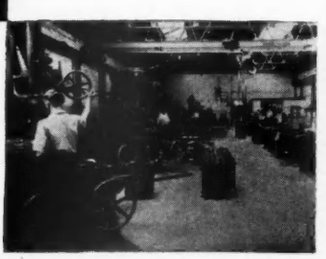

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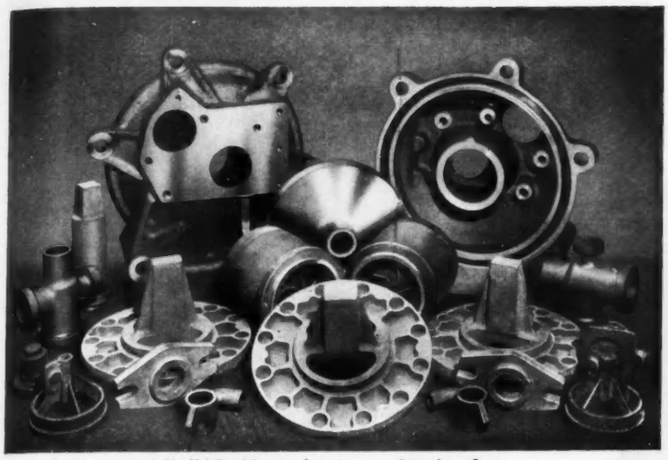

A selection of Shell Mouldings, showing machined surfaces.

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(including Monel)

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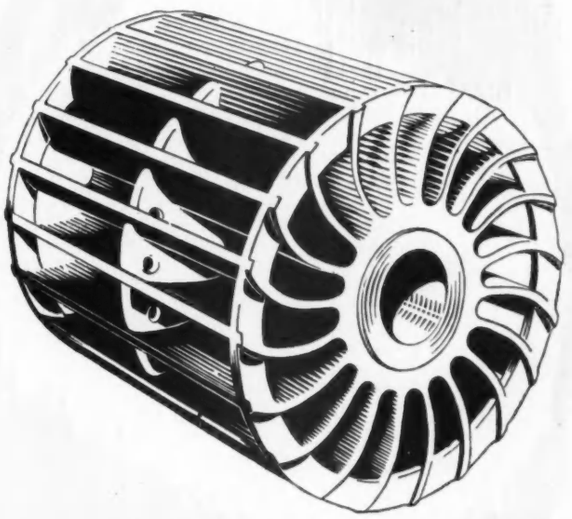

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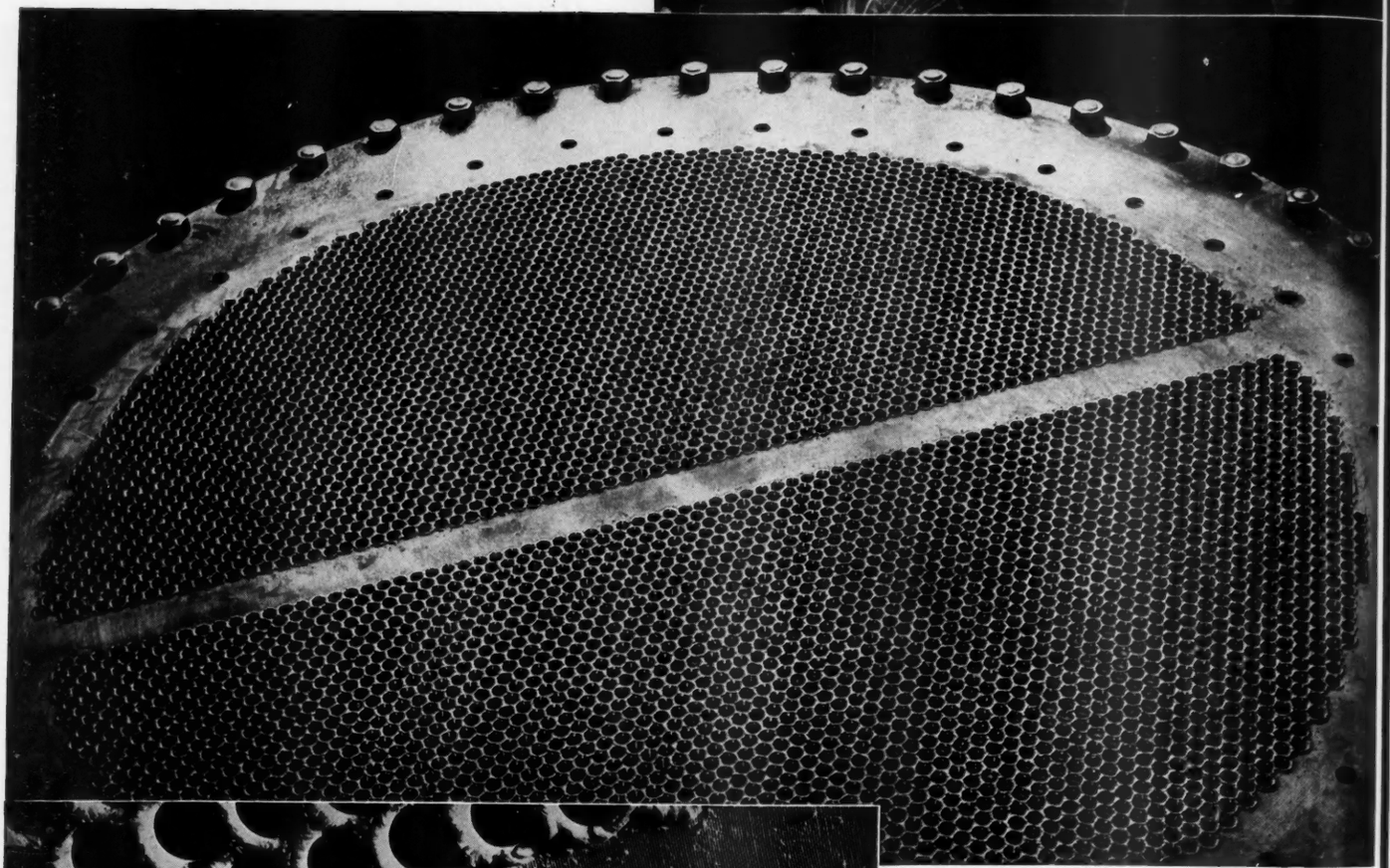

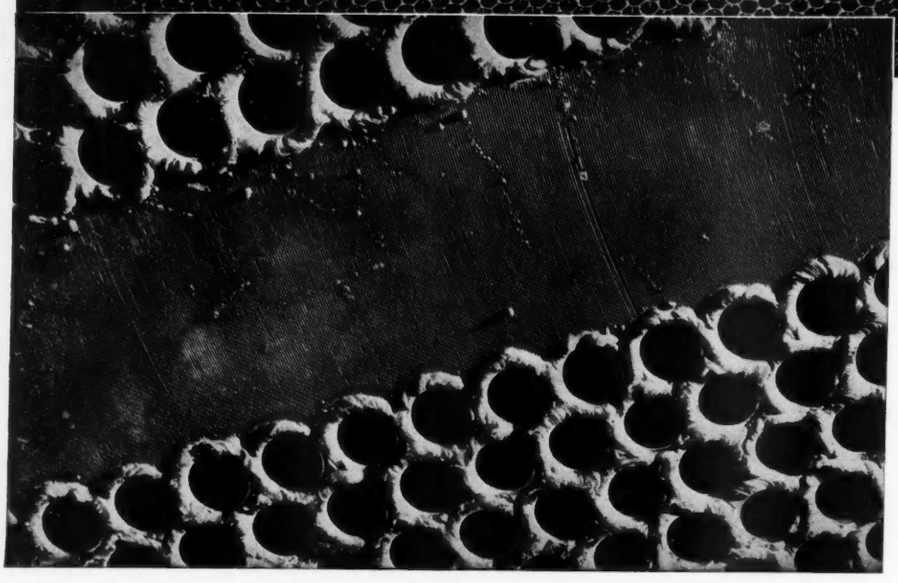

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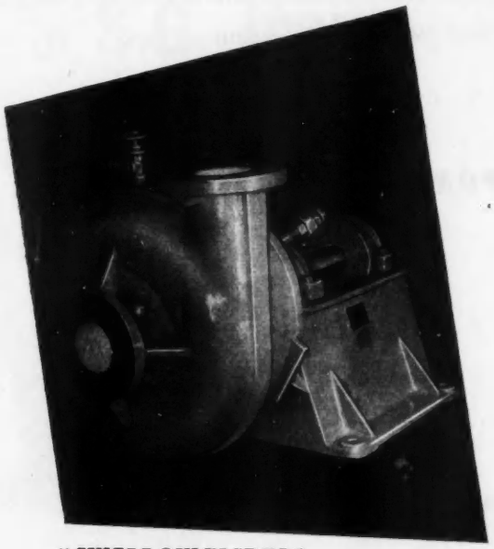

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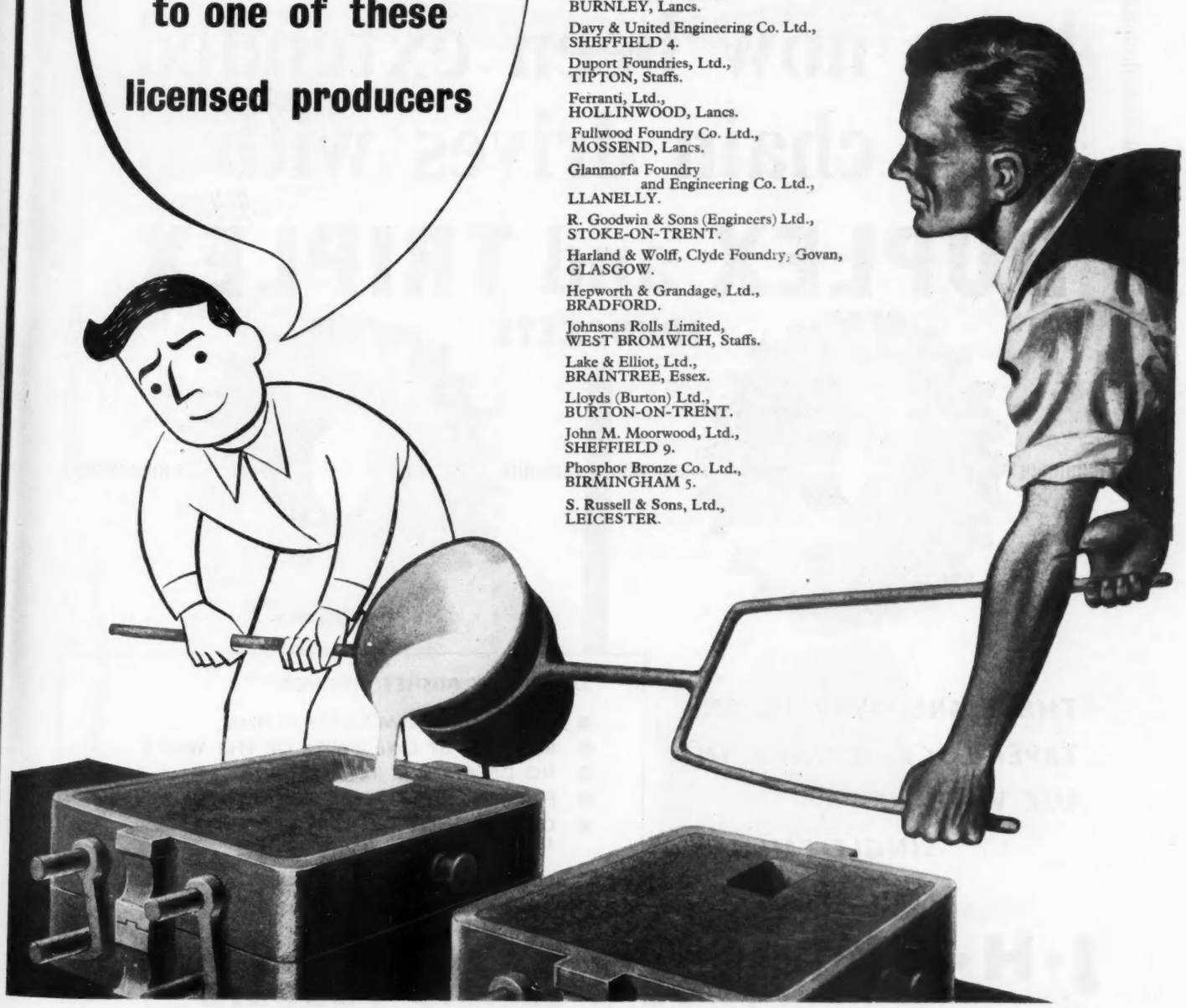

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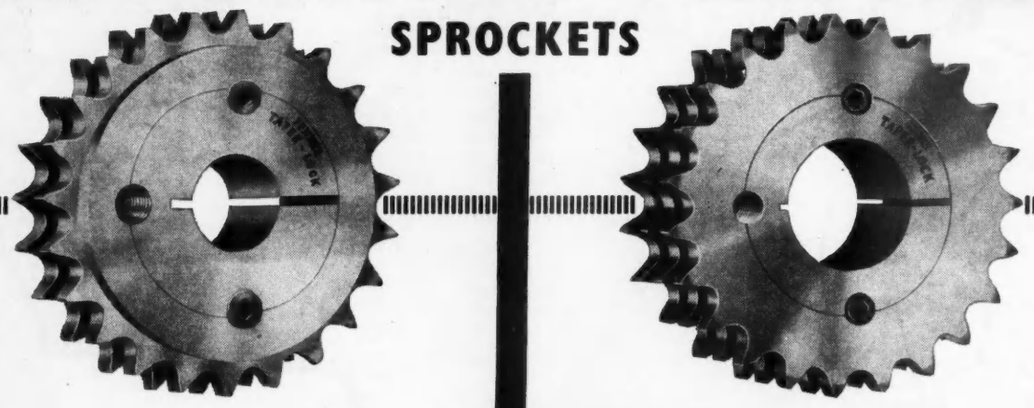

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- *EASY "ON-IN-A-MINUTE" FIXING*
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- *OFF-THE-SHELF DELIVERY FROM 18 BRANCHES*

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LARGEST MAKERS OF V-BELT DRIVES IN THE COMMONWEALTH

Water has its uses . . .

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Found abundantly all over the British Isles, Rana temporaria, the common frog, feeds on insects, worms, slugs etc., taking its food mainly at night. Frogs breed as soon as they emerge from their winter hibernation and then leave the water, living in damp places on land. In coloration, the common frog is most variable and may be grey, olive, brown, yellow or red above, with darker spots and markings.

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Wherever there is falling water a water turbine can be installed—the simplest and most reliable form of prime mover—no fuel bills, long life, little maintenance and requiring only unskilled attention.

GILKES are specialists in the field of small hydro-electric units; we can supply installations to operate on any head from 3 feet to 5,000 feet (or 1 metre to 1,500 metres) and to develop any output up to 1,000 kilowatts on low heads or 10,000 kilowatts on the higher heads.

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1,400 B.H.P. Francis turbine for New Zealand

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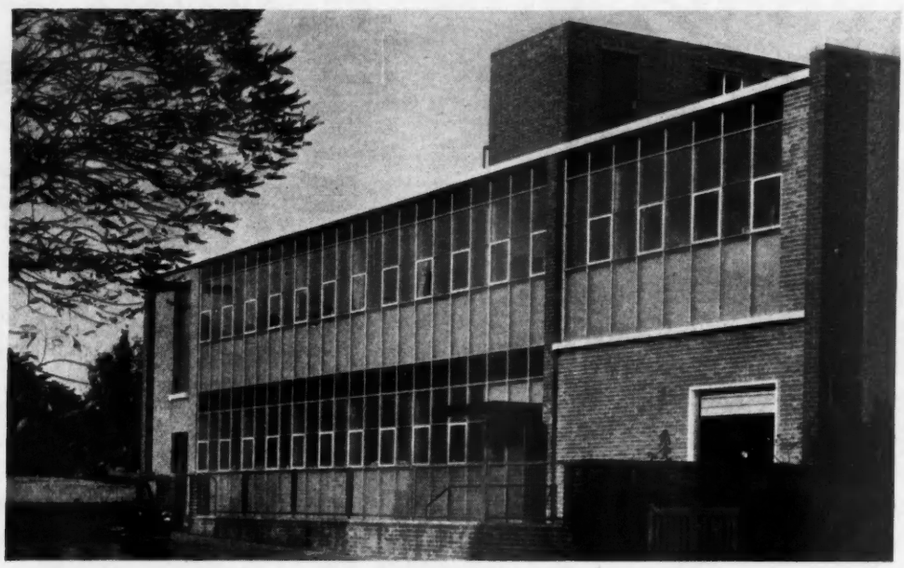
G79

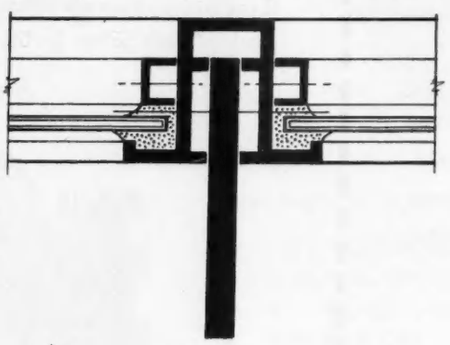
WINDOGRID
Curtain Walling



REMELLA WORKS, FINCHLEY

Alan Howell, A.R.I.B.A., Chartered Architect-Surveyor

Top panes on both floors are glazed with black vitrolite, remainder with broad reedlyte glass, excepting the swing ventilators which have clear glass



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a new 45 ton per hour sand rammer

Parker marches on! New plant, new buildings, new processes are helping Parker craftsmen to give you even better Steel Castings. The whole layout has been re-schemed for the continuous flow production of low carbon steel castings with high magnetic permeability and pearlite manganese steel castings requiring high tensility and exceptional wearing characteristics.

One example of Parker progress is the tractive type Speedslinger ramming machine illustrated above. It is the worlds latest type and one operator mounted jockey wise on the ramming head, can traverse and ram moulds situated anywhere within 20 ft. of his track, at the enourmous rate of 45 tons of sand per hour!

PARKER

steel castings

Manganese, Carbon & Alloy Steel.

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XUM

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(*ROBERT BROWNING*

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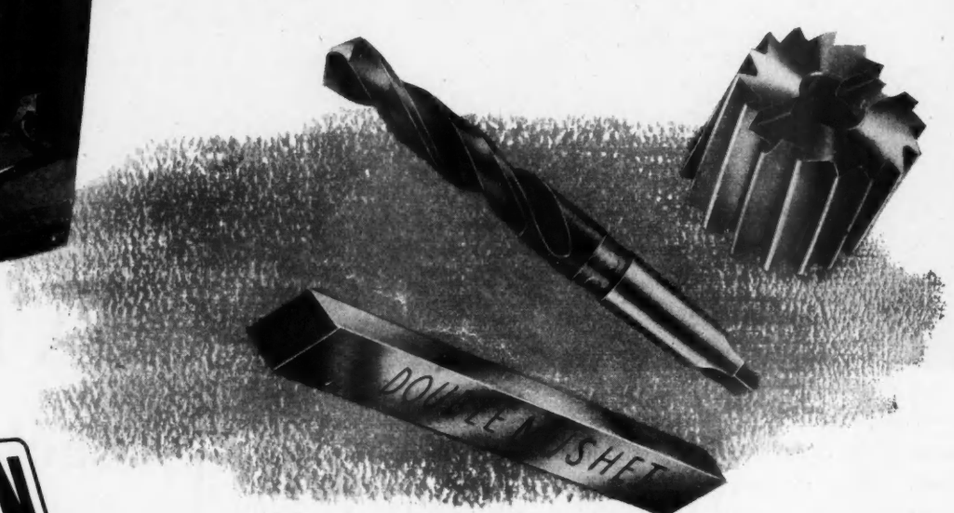
Osborn "Mushet" brands engineers' tools are produced from steels manufactured by the Company, and these twist drills, milling cutters, reamers, lathe tools, etc., are known and used throughout the world. Their production is the result of the accumulated experience from generations of craftsmanship and skill.

"MUSHET" BRANDS



OSBORN

FINE STEELMAKERS · STEELFOUNDERS · ENGINEERS' TOOL MAKERS

SAMUEL OSBORN & CO. LIMITED
CLYDE STEEL WORKS, SHEFFIELD

FERRANTI Transformers for Hydro-Electric Schemes

As specialists in the manufacture of transformers for more than 65 years, FERRANTI LTD. have been associated with many of the world's largest hydro-electric schemes. More recent achievements include contracts for over 4,000,000 kVA of large high voltage power transformers, among which are:—

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GARRISON DAM PROJECT Nine 33,333 kVA, 230,000 volt single-phase Ferranti transformers.

McNARY DAM PROJECT Six 56,000 kVA, 230,000 volt, single-phase transformers.

DALLES DAM PROJECT Eighteen 63,000 kVA, 230 kV and three 63,000 kVA, 115 kV, single-phase transformers.

CANADA

ALCAN PROJECT at Kemano and Kitimat. Seven 71,000 kVA, 301,400 volt single-phase Ferranti generator transformers and six 37,000 kVA, 275,000 volt step-down Ferranti transformers.

CENTRAL AFRICA

KARIBA PROJECT Two 120,000 kVA and ten 60,000 kVA 330,000 volts three-phase Ferranti Transformers. The largest overseas transformer contract ever to be placed in the United Kingdom.

NEW ZEALAND

ROXBURGH AND WHAKAMARU PROJECTS Thirteen 14,800 kVA, single-phase, 50 cycles, 11/220 kV transformers and thirteen 9,259 kVA, single-phase, 50 cycles, 11/220 kV transformers.

INDIA

DAMODAR VALLEY PROJECT Three Ferranti 20,000 kVA, OFB, 3-phase, 50 cycles, 132/33-66 kV transformers and two Ferranti 10,000 kVA, ON/OB, 3-phase, 50 cycles, 132/33 kV transformers.

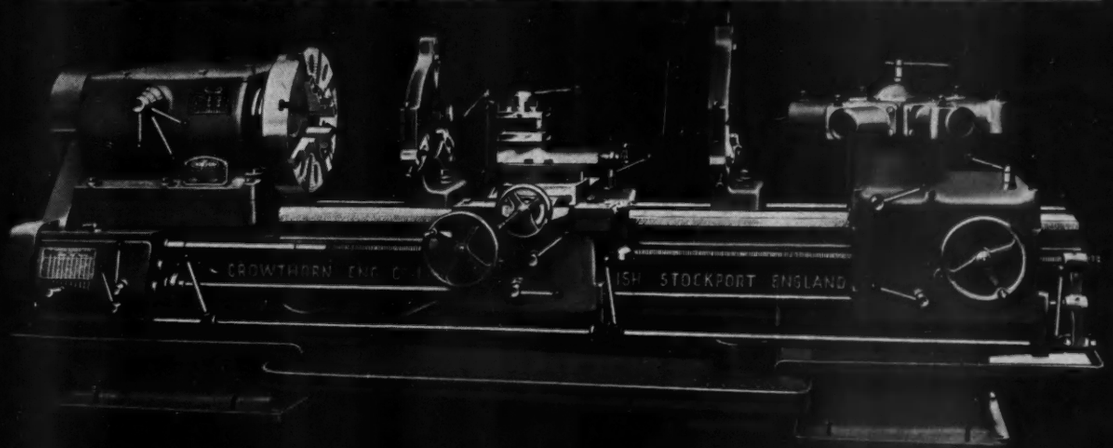
F FERRANTI

FERRANTI LTD · HOLLINWOOD · LANCS

London Office: KERN HOUSE, 36 KINGSWAY, W.C.2.

FT186/2

12½" CENTRE COMBINATION TURRET LATHE



In addition to the model shown we can supply other sizes fitted with heavily built hexagon turret on separate power operated carriage or alternatively in place of the square toolpost.
A machine similar to that shown was supplied to Messrs. W. Sisson & Co. Ltd. of Gloucester for machining engine yokes, etc.

- Swing over bed: 25in.
- Swing in gap: 39in. by 12in.
- Hole through spindle: 3⅛in. diameter
- Bed length: To customers' requirements
- Spindle speed ranges: 10½ to 302 or 15 to 453 r.p.m.
- Inverted vee type slideways
- Timkenised headstock
- Built for accuracy and heavy duty

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HIGH CLASS MACHINE TOOL MAKERS

CROWTHORN ENGINEERING COMPANY LIMITED
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NOZZLE MIXING CUTTER

The most advanced Cutting Blowpipe available today

For full details please write to:

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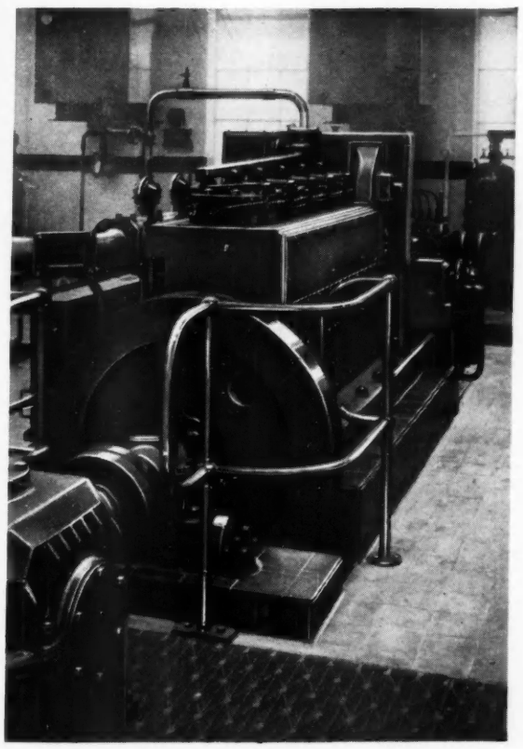
British Oxygen Gases Ltd., Bridgewater House, St. James's, London, S.W.1

slave to industry



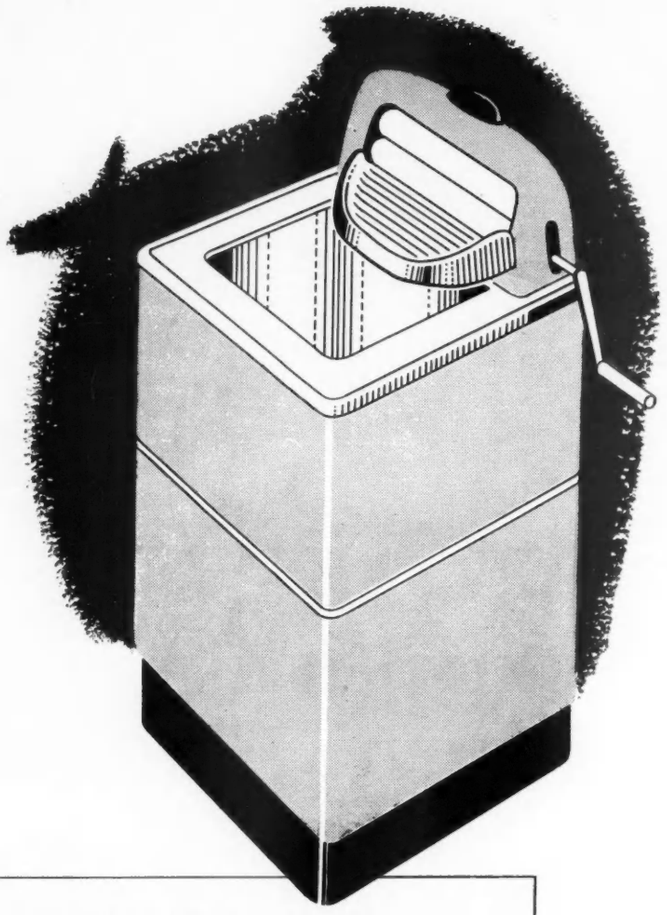
Where lack of space is a problem and power a necessity, the solution is . . . . . *compact power.*

The ant is a perfect natural example of this. His small frame holds remarkable strength, and his capacity for great industry is perfect co-ordination. These are exactly the characteristics of another willing slave to industry . . . . . a Crossley engine. Packing a maximum of power into a minimum of space, they will perform satisfactorily under the most cramped working conditions. The illustration shows one of four two-cycle Scavenge Pump Diesel Engine units working in the Borough of Slough's pumping station. If you feel that this form of concentrated power can solve your particular problem, then Crossley Brothers will be only too pleased to help.

CROSSLEY **COMPACT POWER**

CROSSLEY BROTHERS LIMITED · OPENSHAW · MANCHESTER 11

ΦC404



Coming out in the wash . . .

What, in addition to the weekly wash, goes into a washing machine? Steel to fabricate the body and fashion vital moving parts. Steel whose quality comes out in the long run —in short, steel strip and bars by LEE.
A moving testimony to its quality.

ARTHUR LEE & SONS LIMITED

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TRUBRITE STEEL WORKS
MEADOW HALL · NEAR SHEFFIELD

LEE of Sheffield

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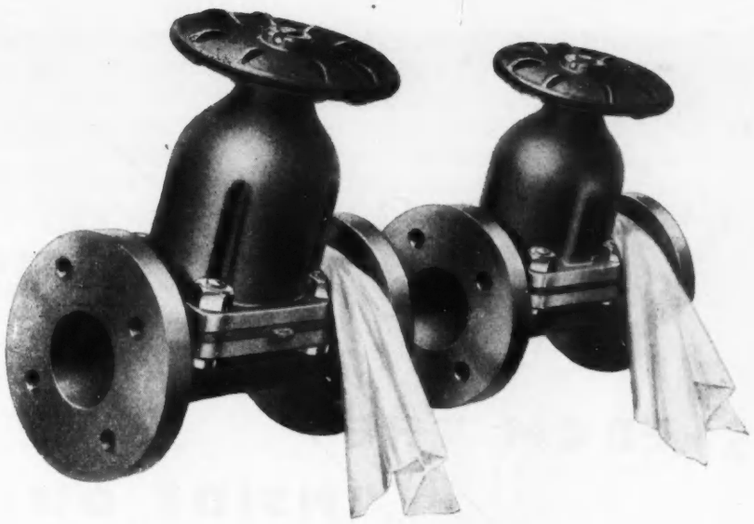


Thick or Clear, Sir?

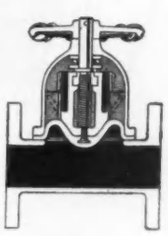
As varied as the human palate is the menu of industrial fluids. Appetite, though making heavy demands upon the Saunders Diaphragm Valve for handling both finished foodstuffs and the fluids involved in manufacture, is but one of the many claims upon a valve with a high sense of hygiene.

No mechanism of a Saunders Valve ever touches an edible fluid (nor can any offensive fluid ever penetrate to that mechanism) which means that the valve is allergic to nothing and is master of all the fluids that flow—and some that tend to stick.

Two main types are available:— Type A which handles anything from Abrasives to Milk or from Mulligatawny to Zinc Sulphide. Type K with straight bore simplifies matters when you are serving Macaroni or Magmata, Mayonnaise, or Colloidal Consommes.

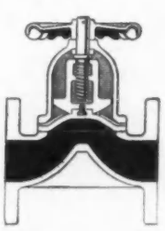
SAUNDERS DIAPHRAGM VALVES

From the great variety of Saunders Diaphragm Valve specifications you will find the combination best suited to the handling of the majority of industrial Fluids. The "List of Applications" in the Saunders Handbook explains this versatility.



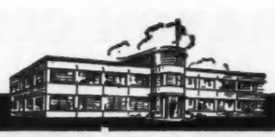
TYPE 'K'

The straightest of straight bores allows maximum fluid flow and permits rodding-through for the clearance of built-up deposits of not-so-fluid fluids.



TYPE 'A'

Handles fluids as simple as air and water, as delicate as foodstuffs and medicines and as difficult as chemicals and abrasives.



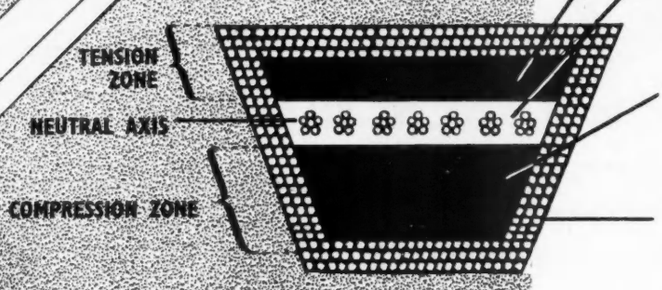
SAUNDERS VALVE COMPANY LIMITED

DIAPHRAGM VALVE DIVISION

CWMBRAN - NEWPORT - MONMOUTHSHIRE

Designed

FROM THE INSIDE OUT!



Elastic rubber cushion withstands bending stresses

Load-bearing high tenacity rayon cords embedded in friction-absorbing gum rubber

Controlled wedging action of volumetrically correct compression cushion ensures low slackside tension, true running and high horse power transmission factor

Tough outer cover of rubber impregnated cotton duck, bias cut for greater flexibility, gives maximum wear resistance and grip

MADE TO B.S. 1440/1948

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RAYON CORD V BELTS

TURNER BROTHERS ASBESTOS CO. LTD. ROCHDALE ENGLAND

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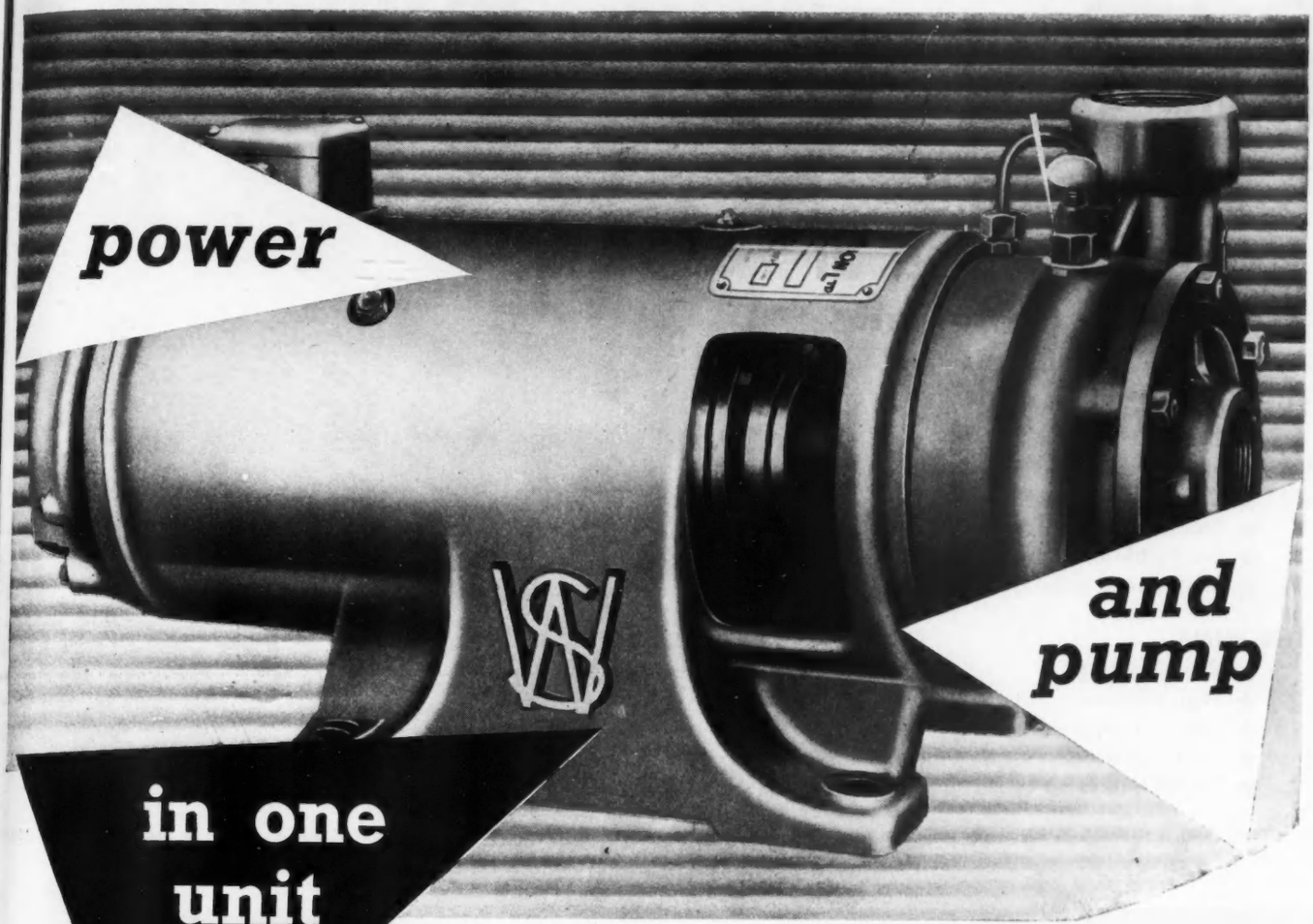

The unit construction of Monobloc Pumps eliminates the necessity of providing separate driving motors, bedplates, belts, pulleys and couplings. The single shaft ensures perfect and maintained alignment — working parts are reduced to a minimum — space is saved and installation made easy. The pumps will operate in any position, including vertically, providing the pump is below the motor.

MONOBLOC

centrifugal pumps

Patent No. 591835

RANGE 3 — 1200 GALS. PER MINUTE
HEADS UP TO 375 FT.
¼ TO 30 B.H.P.
ALL STANDARD VOLTAGES

For varied purposes including

AIR CONDITIONING · BRINE CIRCULATION
CIRCULATING SYSTEMS · DRAINING · FILTERING
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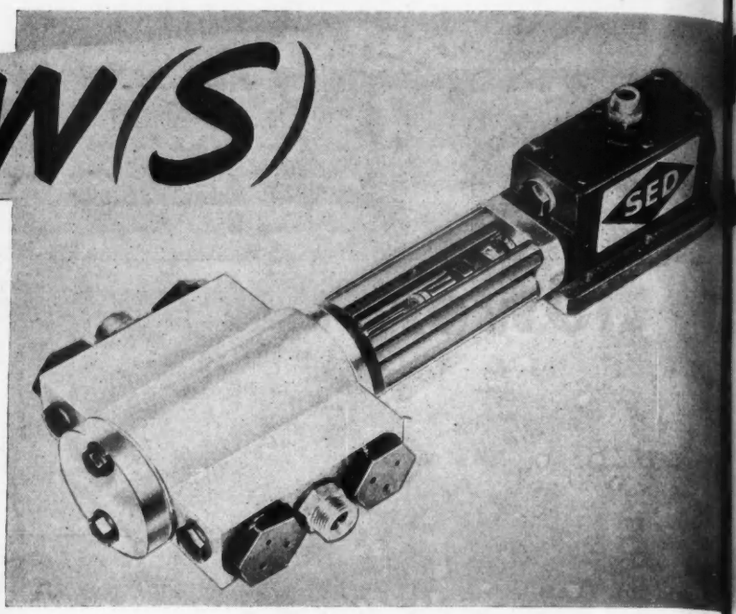
The S.E.D
'NEUMO' Mk. III
PNEUMATICALLY OPERATED PUMP UNIT



THE MOTOR

- ★ Two moving parts only.
- ★ Hardened and ground piston and valve.
- ★ Cast iron body with honed bore.
- ★ Non-stalling.
- ★ Negligible air consumption.
- ★ High power output.

THE PUMP

- ★ Double acting.
- ★ High efficiency.
- ★ Self-contained valves.
- ★ Easily serviced.
- ★ Pumps liquids up to 200 deg. F.

SIMPLICITY MEANS RELIABILITY

TYPICAL PERFORMANCE FIGURES

Air Pressure	60 lbs. P.S.I.	60 lbs. P.S.I.
Consumption	2½ Cu. F.P.M.	2½ Cu. F.P.M.
Delivery	45 gals. P.H.	120 gals. P.H.
Del. Pressure	30 lbs. P.S.I.	5 lbs. P.S.I.

WIDE RANGE

Owing to the design and materials employed in construction, the "Neumo" Mk. III Pump Unit capable of handling a very wide range of materials as paint at 200 deg. F., petrol, oils, from paraffin to high viscosities, Solvex, Mangersol, Basol, Trichlorethy and all types of cellulose solvents, etc.

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(Dept. EG), KINGSBOURNE PRODUCTS LTD., SOUTH COAST ROAD, PEACEHAVEN, SUSSEX **Tel. Peacehaven 2115**

CRUSTEX
A SOUND SAVING ON A BIG SCALE

... SEE WHY IT'S THE ONLY MODERN METHOD OF BOILER DESCALING

Once installed in your plant, Crustex removes all scale except for a protective egg-shell thick blanket that increases boiler life without reducing thermal efficiency.

NO SHUT DOWNS —— NO BREAKDOWNS

★ **YOUR BOILER NEVER NEEDS DESCALING ONCE CRUSTEX IS ESTABLISHED IN YOUR PLANT**

BECAUSE it's Absolute

No scale can resist the Crustex ultrasonic action.

BECAUSE-it's Constant

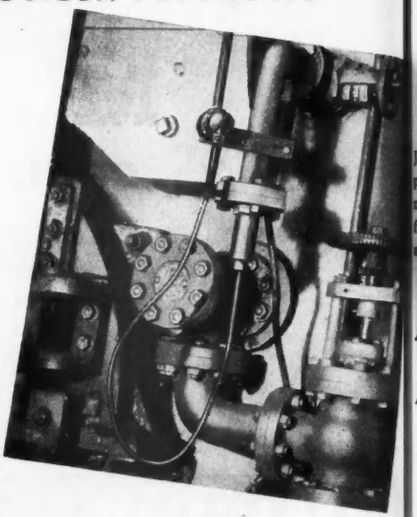
Crustex—the perpetual guardian—is always acting to keep Boilers clean.

BECAUSE-it's Safe

Crustex leaves a thin blanket of scale to protect boiler walls, lengthening the life of your plant.

BECAUSE-it's Cheaper

Saves fuel and labour, needs no maintenance and costs £1 per year current consumption.



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Rochelle Works · Brixton Hill Place · London S.W.2
Telephone: TULse Hill 3251 *Telegrams:* PENDANTS BRIX

Overseas Agent.
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Rainbow 1174

Industry's most versatile cranes

Jones Cranes can be supplied on pneumatics, crawlers or flat base and on lorry mounted or rail mounted chassis. Capacities from 15 cwt. to 7½ tons. Jibs of all types available, including cantilever.

EARLY DELIVERY

Hire purchase terms arranged

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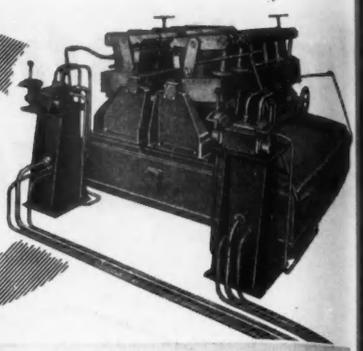
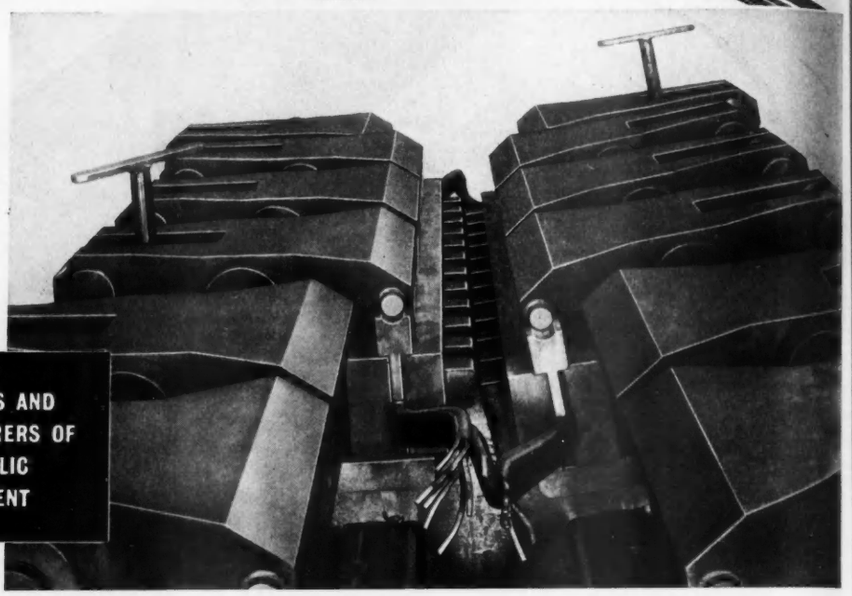
THE 600 GROUP OF COMPANIES

Jones cranes

COIL PRESS

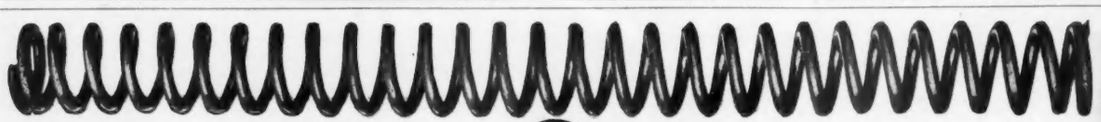


Specially developed for the electrical industry, the press illustrated is one example of the variety of machines we supply to customers' requirements.



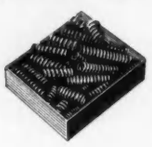
LEH DESIGNERS AND MANUFACTURERS OF HYDRAULIC EQUIPMENT

THE LEEDS ENGINEERING & HYDRAULIC CO. LTD., RODLEY, LEEDS · Telephone: 'PUDSEY' 2859

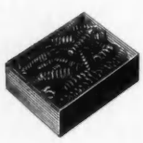


No. 1013. 1 gross Small Coil Compression Springs, ½" to 1½" long, 3/32" to 7/16" diam., 24G to 19G. 6/- each

No. 760. 3 doz. Assorted Light Compression Springs 1" to 4" long, 22 to 18 S.W.G., ¼" to ½" diam. 6/6 each.



No. 98A. 3 doz. Assorted 1" to 4" long. ¼" to ⅝" diam. 19G to 15G. 5/6 each



No. 757. Extra Light Compression. 1 gross Assorted. ¼" to ⅝", ½" to 2" long, 27 to 20 S.W.G. 15/- each.

No. 388. ½ gross Assorted Small Expansion Springs. ¾" to 1½", 18G to 21G. 9/6 each.

No. 466. ½ gross Assorted Small Expansion Springs ⅜" to 1½" long, 3/32" to 3/16" diam., 21G to 24G. 6/6 each.

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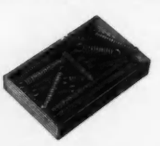

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No. 758. Fine Expansion Springs, 1 gross Assorted ¼" to ⅜", ½" to 2" long, 27 to 20 S.W.G. 15/- each.

How are you off for Springs?

TERRY'S BOXES OF ASSORTED SPRINGS are just the job for your experimental department—a wonderful assortment of Compression and Expansion Springs... all sorts of lengths, gauges, diameters. The nine boxes we show are just a few from our range. Why not let us send you a full list—free?

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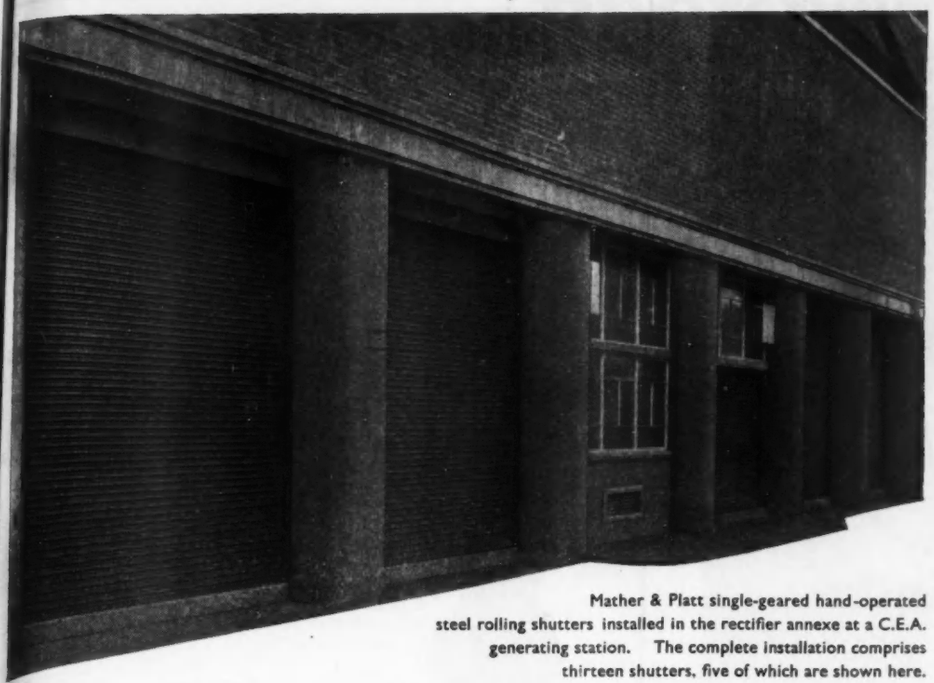

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HAND OPERATED
OR ELECTRICALLY OPERATED

STEEL ROLLING SHUTTERS

FOR ENTRANCES TO TRANSIT SHEDS, TRANSPORT DEPOTS, GARAGES, POWER STATIONS, BOILER-HOUSES, WAREHOUSES, HANGARS AND NUMEROUS OTHER TYPES OF COMMERCIAL AND INDUSTRIAL PREMISES.

The high quality of materials and workmanship employed in the manufacture of Mather & Platt steel rolling shutters ensures reliability and long service, and the excellence of their design and construction is the result of practical engineering experience and continuous research during the firm's 150 years of existence.

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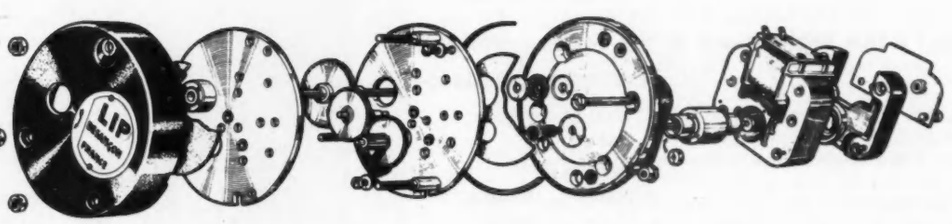
638

LIP synchronous and asynchronous electric micromotors are guaranteed by a standing custom of quality and clock-work precision.



More than 75 % of the small motors in service now in France (that is to say 300.000 motors) are **LIP** motors.

Advantages : **Solidity - Little space required - No consumption - Extensive speed range - No atmospherics - No upkeep.**

In 15 years, 376 different applications.

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ALJANVIC 148

Now, here's a specimen of Ferobestos...

it's an asbestos-based material—non-metallic, of course—impregnated with resins and moulded into a hard infusible substance. Ferobestos Plastics are not substitutes . . . they're engineering materials in their own right. Ferobestos plastics have many advantages which can be (and have been) put to use by engineers in many industries:—

- high strength-to-weight ratio
- high temperature resistance
- low moisture absorption
- good chemical resistance
- high wear resistance
- good electrical resistance
- high dimensional stability

Here are just a few applications of the various grades of Ferobestos plastics:—

Ferobestos Plastics are usually supplied in sheets, rods and tubes, but they can also be moulded to your requirements where contour permits, and where quantity justifies the cost of mould tools. All forms of machining are carried out for you where necessary. *Interested? Then why not write to J. W. Roberts Ltd., for their leaflet giving fuller details of these versatile materials.*

- Bushes
- Coupling Discs
- Guides . Bearings
- Gears . Rollers
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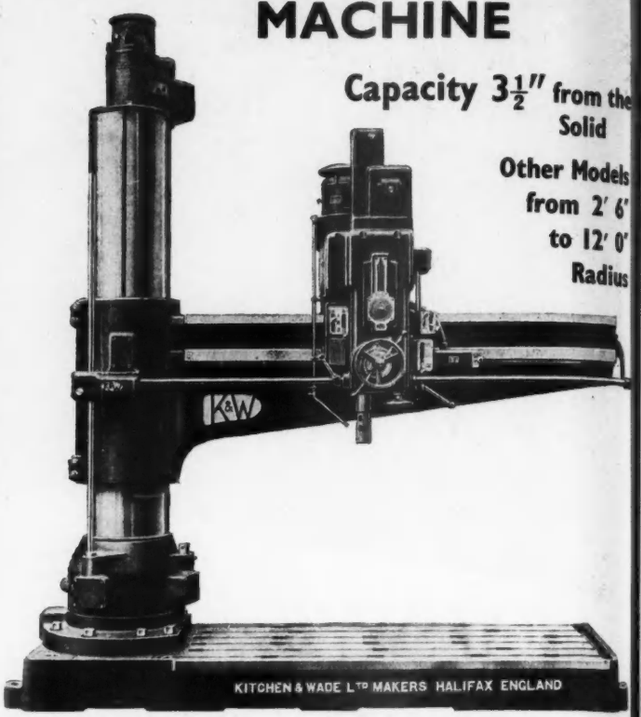
9'0" E28 RADIAL DRILLING MACHINE

Capacity 3½" from the Solid

Other Models from 2' 6" to 12' 0" Radius



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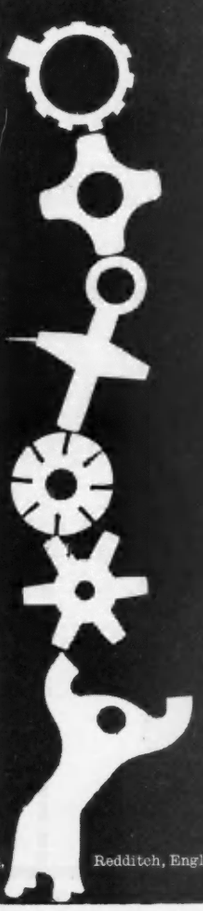
HALIFAX, ENGLAND



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It's difficult to strike a balance but here are a few of the tens of thousands of precision pieces of presswork we produce each day for every imaginable type of engineering task large or small. We should welcome the opportunity to show you some of the manufacturing tricks we have up our sleeve. Our Research Department would be pleased to put their long experience at your disposal and a catalogue is yours for the asking.

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presswork and springs

Backed by over 100 years' experience.

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PECKETT diesels

For nearly a century Pecketts have stood among the foremost builders of Industrial Locomotives. Now, after years of design development and rigorous testing, comes the Peckett diesel locomotive, robust as its steam predecessors and setting new standards in simplicity of operation and all-round economy and employing for the first time in any locomotive . . .

fully automatic mechanical transmission

Developed in conjunction with Hobbs Transmission Limited, the 4-speed mechanical gear box is fully automatic —control being by throttle and reversing lever only. Acceleration and change of direction are exceptionally smooth and rapid even by current standards, and the principle of operation is such that wear in the gear box is almost negligible, reducing maintenance to a minimum.

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Builders of Industrial Locomotives for almost a century.

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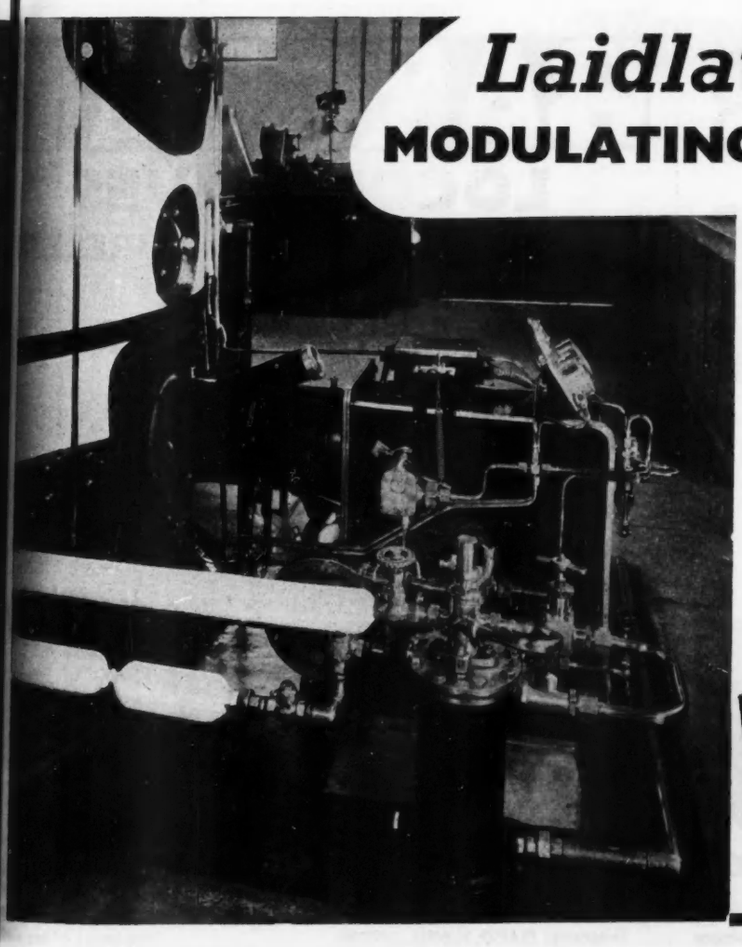
Ask for brochure "Peckett Diesel Locomotives" which describes and illustrates general construction together with a detailed explanation of fully Automatic Mechanical Transmission.



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for all grades of fuel oil up to 950 sec. Redwood No. 1 at 100°F. and for capacities up to 800 lb. of oil per hour.

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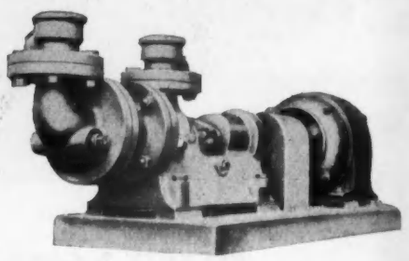

The principle of the Mono Pump is often likened to the Archimedean Screw, but whereas the Screw is a simple means of lifting water it does not create a vacuum and use atmospheric pressure as an automatic primer and lifter.

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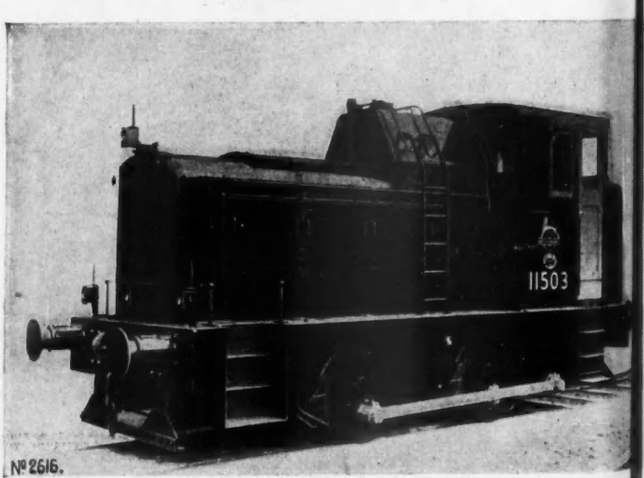

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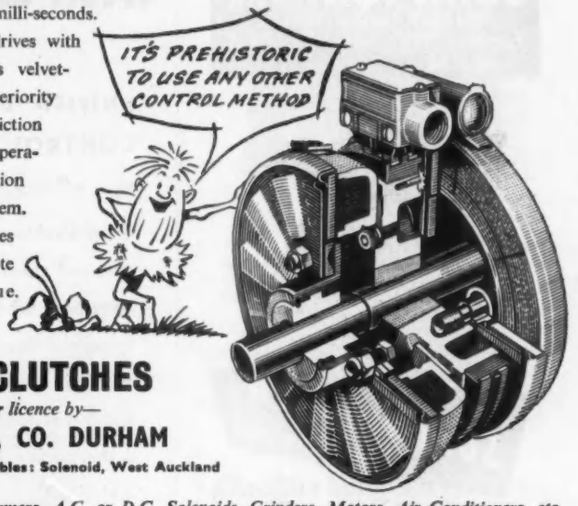

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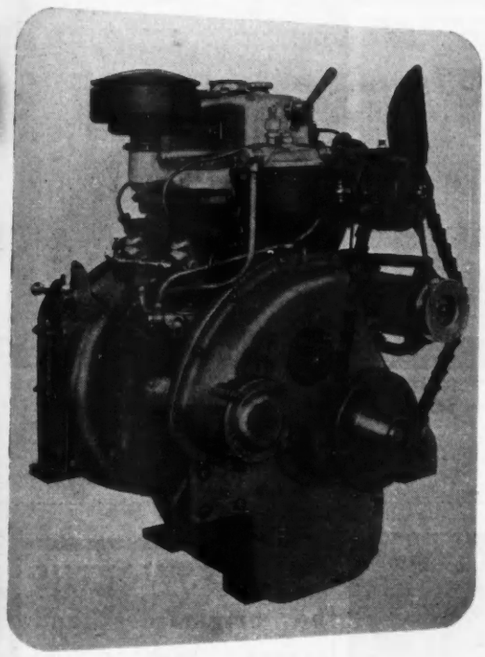

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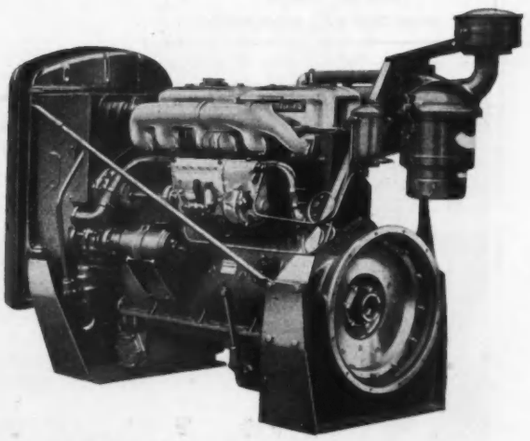

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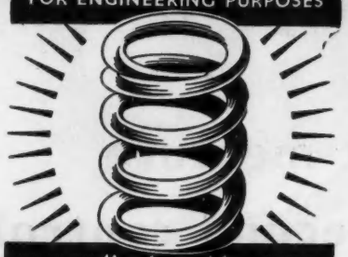

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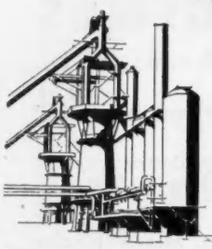

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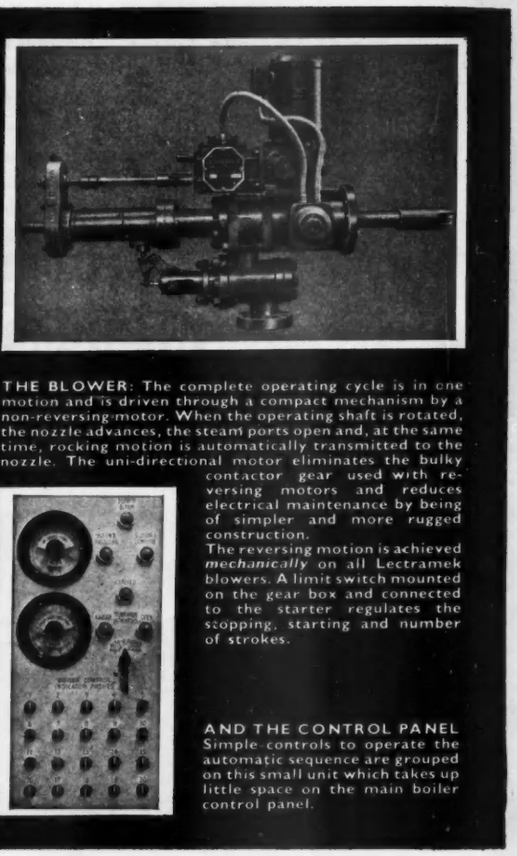

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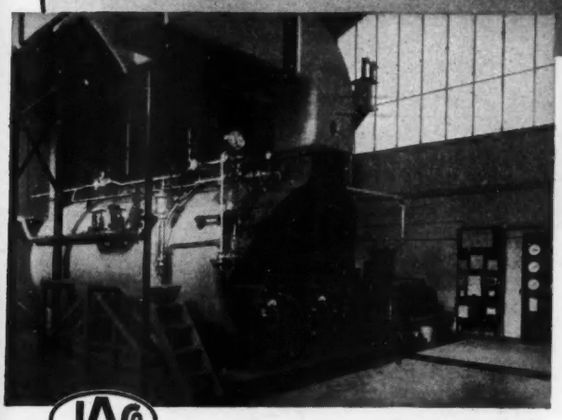

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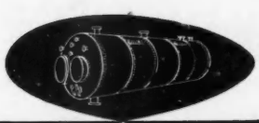

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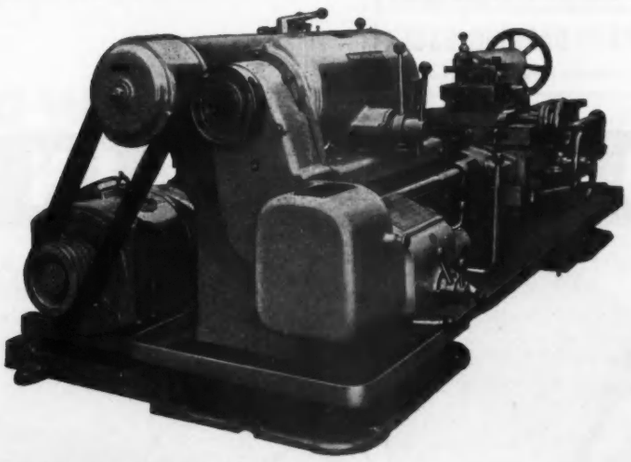

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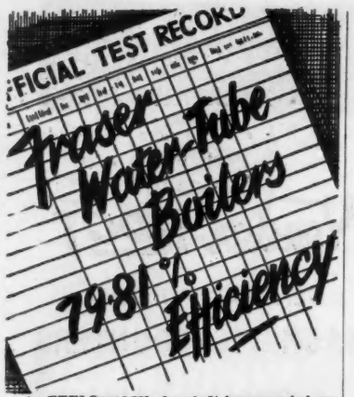

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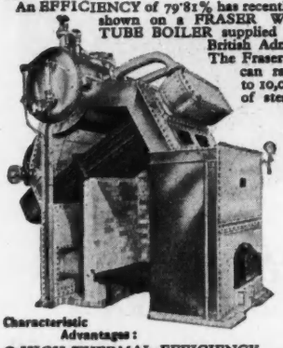

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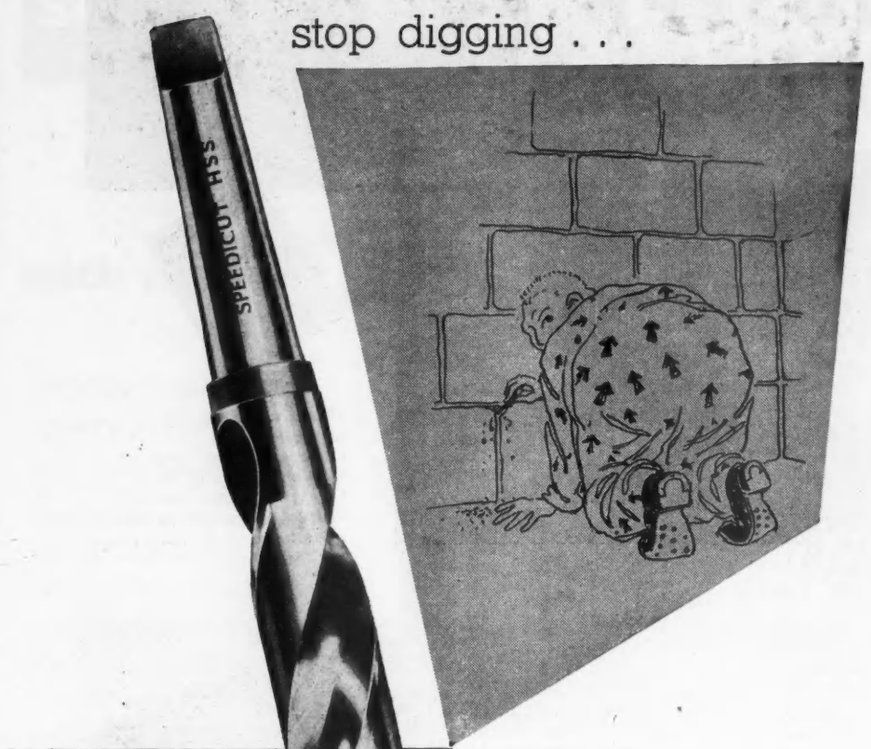

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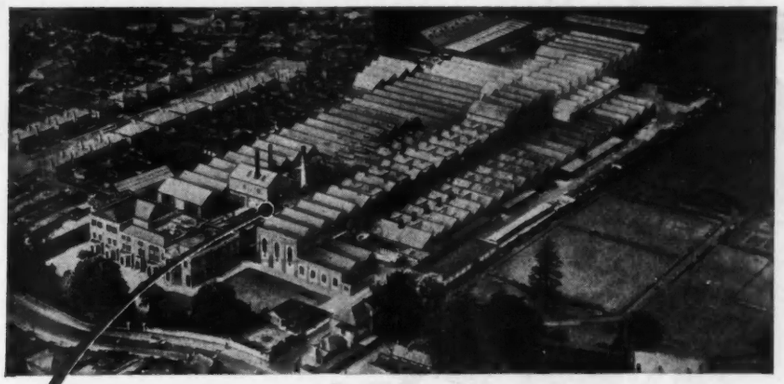

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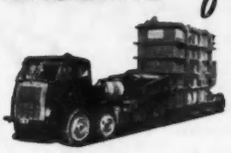

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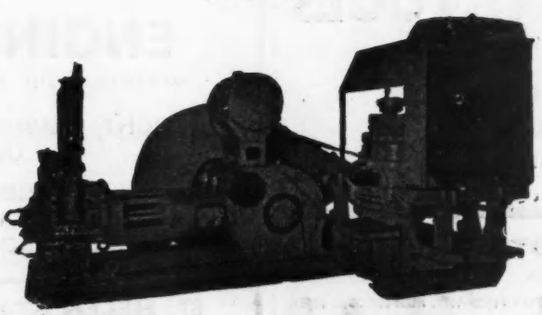

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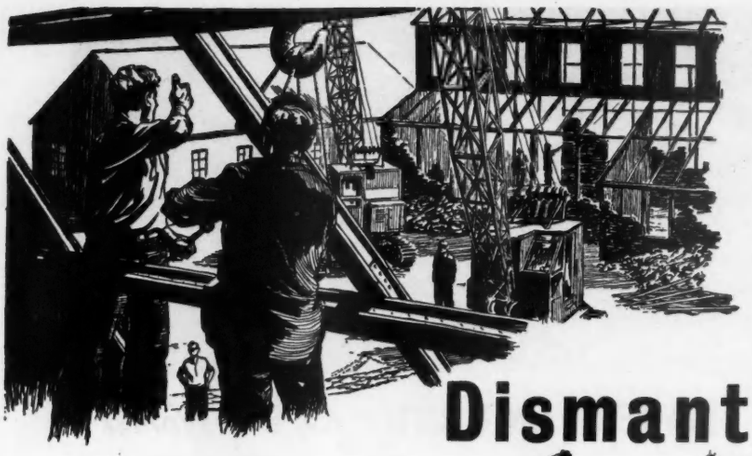

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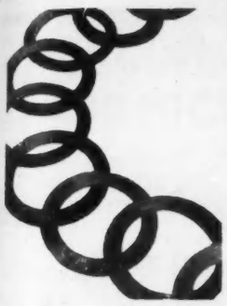

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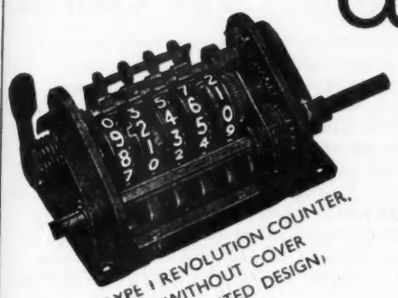

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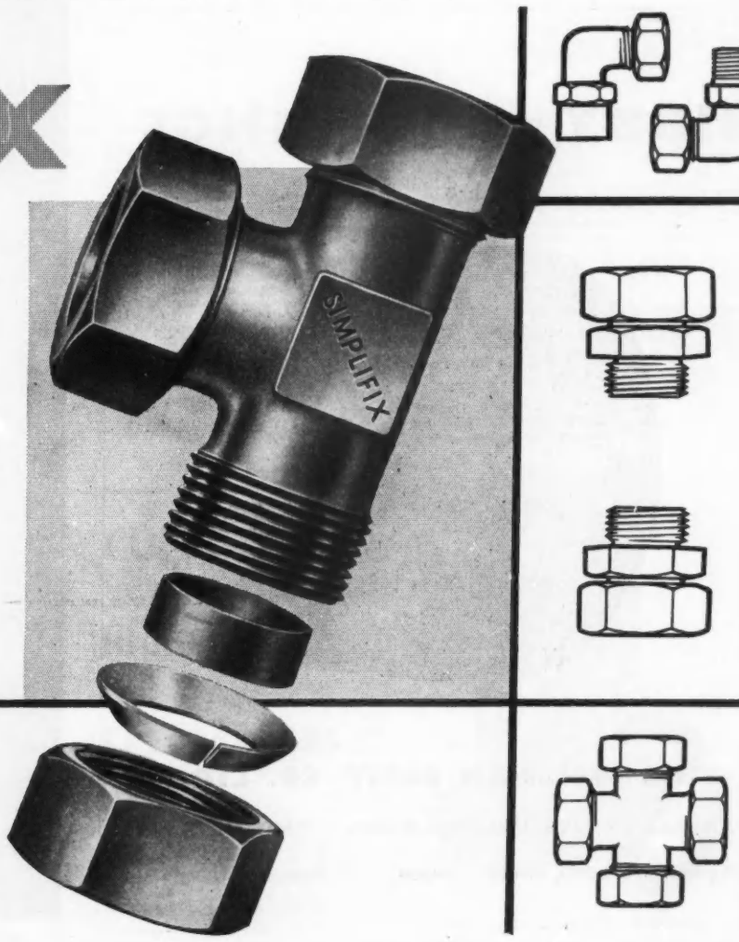

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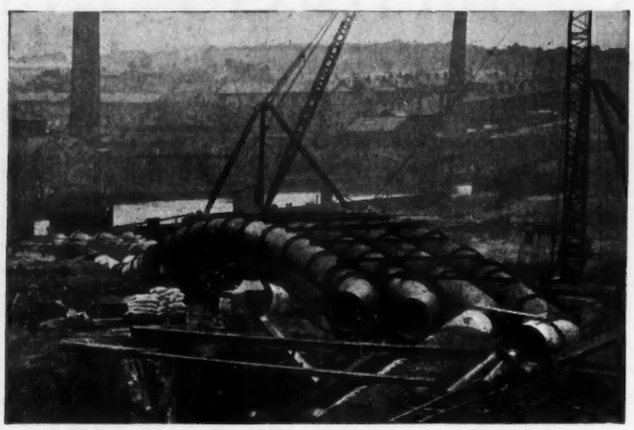

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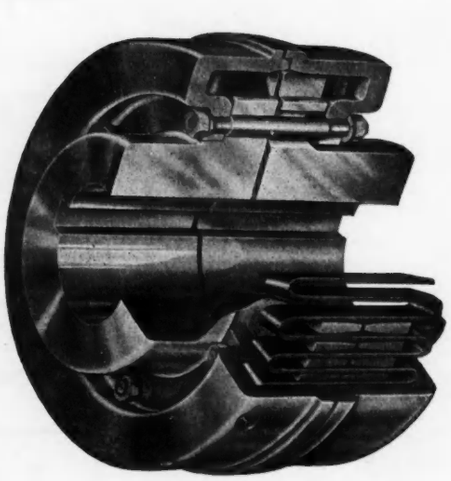

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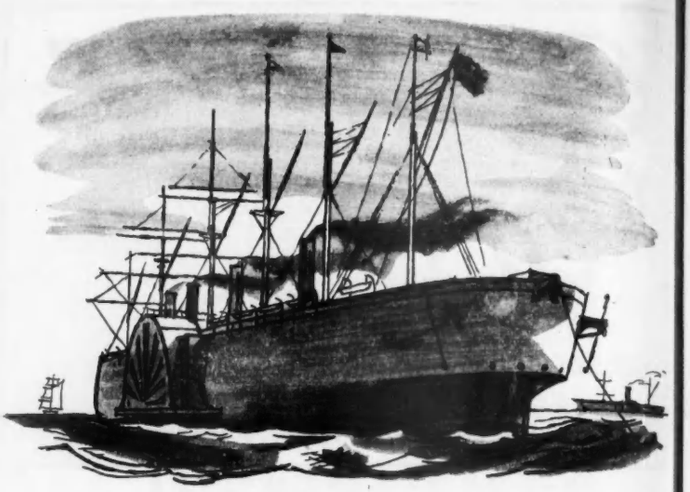

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Classified Advertisements continued from Page 3

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Wilton is situated at the foot of the Cleveland Hills, between Middlesbrough and the coast, and is clear of the industrial smoke belt. Working conditions and recreational facilities are first class.

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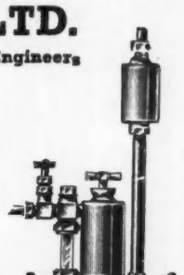

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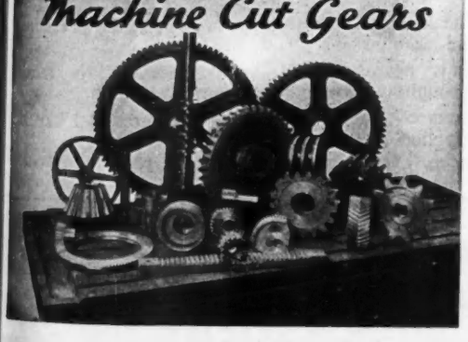

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DISTRICT (CIVIL) ENGINEER required by British Railway Company operating Chile. Sterling salary, retirement benefits, free quarters, passages home leave, allowances, etc.—Write to BOX No. 598, c/o CHARLES BARKER & SONS, LTD., GATEWAY HOUSE, LONDON, E.C.4. P 372

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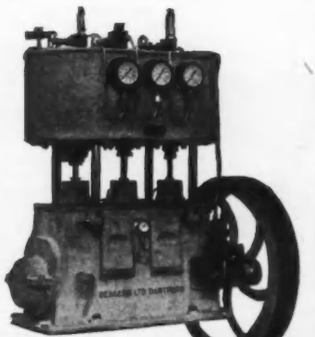

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P 371

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Specialists in the field of Automobile and Aircraft components, invite applications from young men who have recently completed, or are about to complete, their Engineering Apprenticeship or Drawing Office Training, for posts as:—

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These positions offer excellent opportunities to men seeking further Drawing Office experience in preparation for careers in Design or Production Engineering. Minimum qualifications, O.N.C.

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Appointment will carry seat on the Board. Responsible to the Managing Director for Production, Sales and Technical Development.

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Essential qualities are a capacity to handle at top management level a wide range of technical and commercial problems and a genuine interest in modern management techniques.

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P 374

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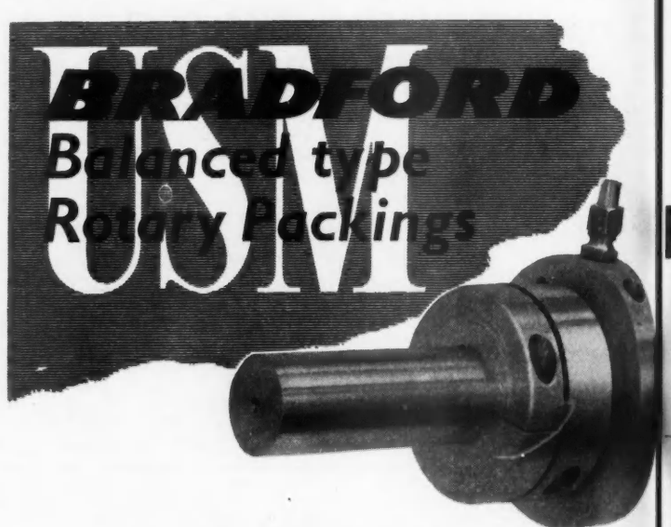
Wilton is situated at the foot of the Cleveland Hills in Yorkshire, five miles from the coast and clear of the industrial smoke belt. Working conditions and recreational facilities, including football, cricket, tennis, golf, badminton, and archery, are first class. If you want an interesting and rewarding job helping to design the British Chemical Industry of the future, please write to me:—The Staff Manager, Imperial Chemical Industries Limited, Wilton Works, Middlesbrough, Yorkshire, quoting 360/5. P 328



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SENIOR DRAUGHTSMAN wanted for detailing and checking of Production Drawings. Good salary, attractive Pension Scheme, pleasant working conditions. Apply CHIEF PERSONNEL OFFICER, BRYCE BERGER, LIMITED, IRONBARKS WORKS, STAINES, MIDDX. G 601

INSPECTOR OF WORKS required by Consulting Engineers for Civil Engineering construction of a Dock at Hull.—Apply SIR BRUCE WHITE, WOLFE BARRY & PARTNERS, 1, LYGON PLACE, GROSVENOR GARDENS, S.W.1. Tel.: Sloane 0431. P 358

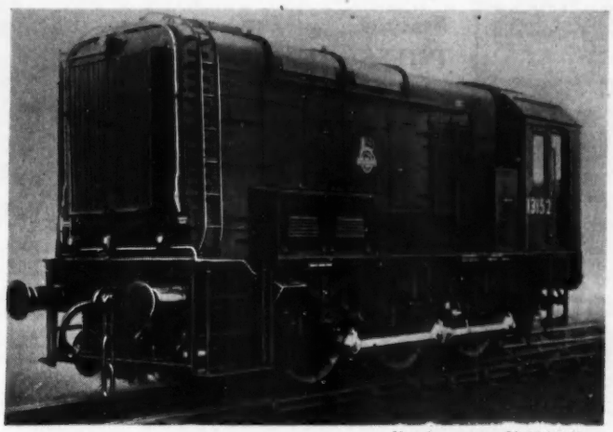
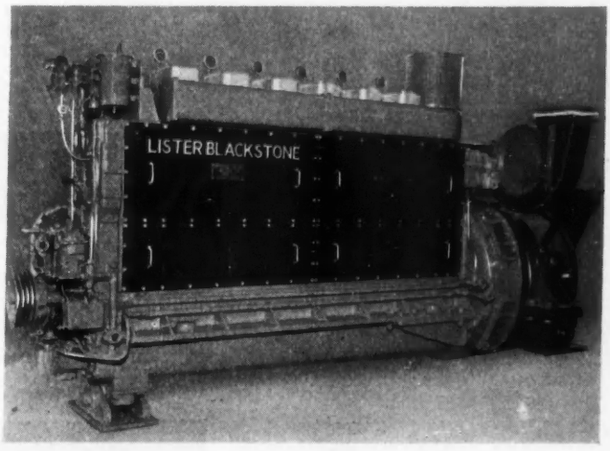


Photo by courtesy of British Railways

One of British Railways Diesel Electric Shunting Locomotives equipped with Lister Blackstone 350 b.h.p. Diesel Power Unit.

LISTER BLACKSTONE



Power Unit as installed in Diesel Electric Shunting Locomotives for British Railways incorporating G.E.C. electrical equipment.

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Diesel engines up to 600 h.p.

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Large expanding light engineering Company in the South Midlands is prepared to engage a selected number of Young Men (23-30) for training through technical work, foremanship and on eventually to Managerial Posts. Qualifications required:

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Applicants must be prepared for factory hours during training (including nightshift if necessary) and to work hard for a number of years to fit themselves for the higher posts in engineering industry. Apply in own writing giving age, qualifications, present salary and career to date in chronological order.

BOX P 301, Offices of ENGINEERING.

THE BRITISH ERMETO CORPORATION, LTD., Manufacturers of Valves and Couplings for High Pressure Installations, require

TECHNICAL REPRESENTATIVES. Applicants must have had a wide practical experience and a good technical education. The Corporation operates a contributory pension scheme with life insurance cover. Starting salary will depend on past experience and special qualifications for this appointment but will not be less than £1000 p.a. Vacancies exist in North England and the South Midlands. Successful applicants will be given a period of instruction at the Company's headquarters at Maidenhead.—Apply in writing giving age and brief particulars of past experience.—BEACON WORKS, HARGRAVE ROAD, MAIDENHEAD, BERKS. P 326

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holding H.N.C. or O.N.C.

are invited to apply for posts in the Mechanical Engineering Laboratories of the English Electric Company, recently established in rural surroundings near Leicester. These Laboratories are undertaking research and development work on a wide variety of problems—welding, lubrication, thermodynamics, fluid dynamics, structures, mechanisms. Important fields of application of the work are:—

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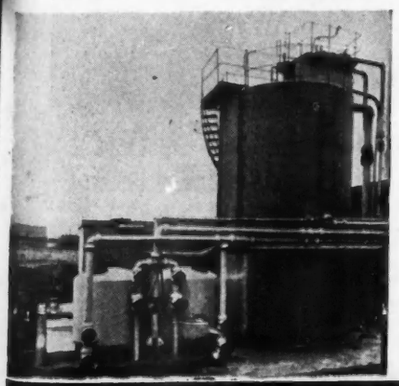

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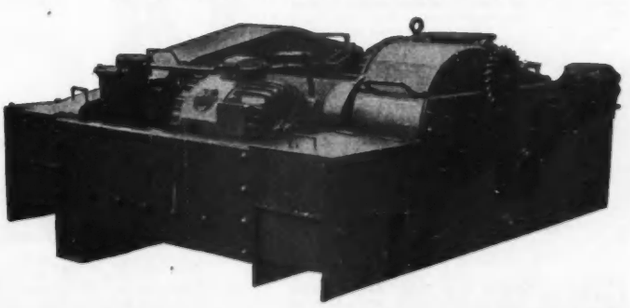

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P 340

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ABELSON offer the following standard gauge **STEAM LOCOMOTIVE** for immediate sale:—
ONE HAWTHORN LESLIE 0-4-0 STEAM SHUNTING LOCOMOTIVE with 14-in. cylinders, suitable for 4 ft. 8½ in. gauge.
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ABELSON offer the following standard gauge coal-fired **STEAM LOCOMOTIVE CRANES** for immediate sale :—
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20 TON CAPACITY, 3 MOTOR TYPE, CABIN CONTROLLED OVERHEAD ELECTRIC TRAVELLING CRANE by Vaughan, 500 v. D.C., 63 ft. span, 30 ft. lift, lattice girder type.
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Makers of
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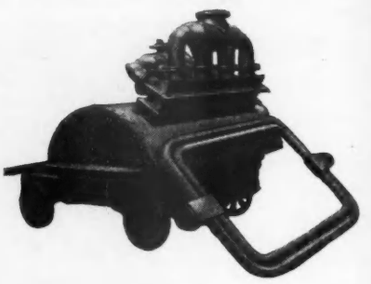

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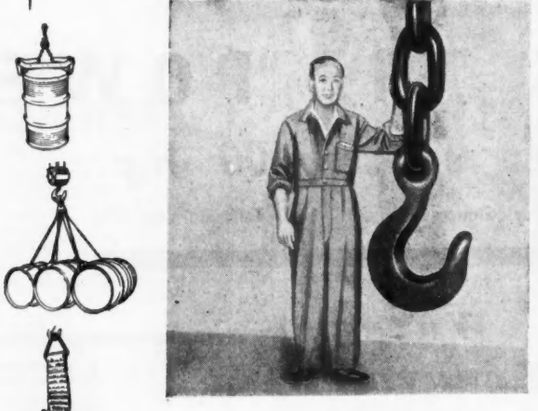

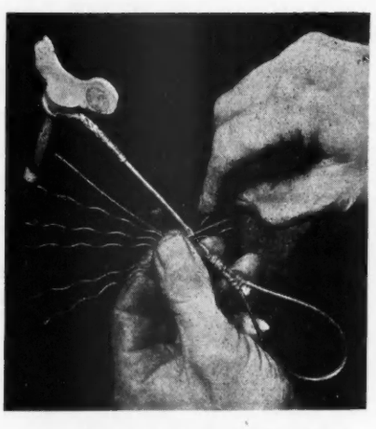

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TWW

71 H.P. VERTICAL SIX CYLINDER RADIATOR COOLED COLD STARTING OIL ENGINE BY FOWLER, Type 6B, speed 1300 r.p.m., cyl. 4½ in. bore by 6½ in. stroke, fuel tank, water circulating pump, air filters, radiator, flywheel 24 in. by 4½ in. face, etc.

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Table size 52½ in. by 14 in.
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Table size 27 in. by 7½ in.
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SOAG MACHINE TOOLS LIMITED
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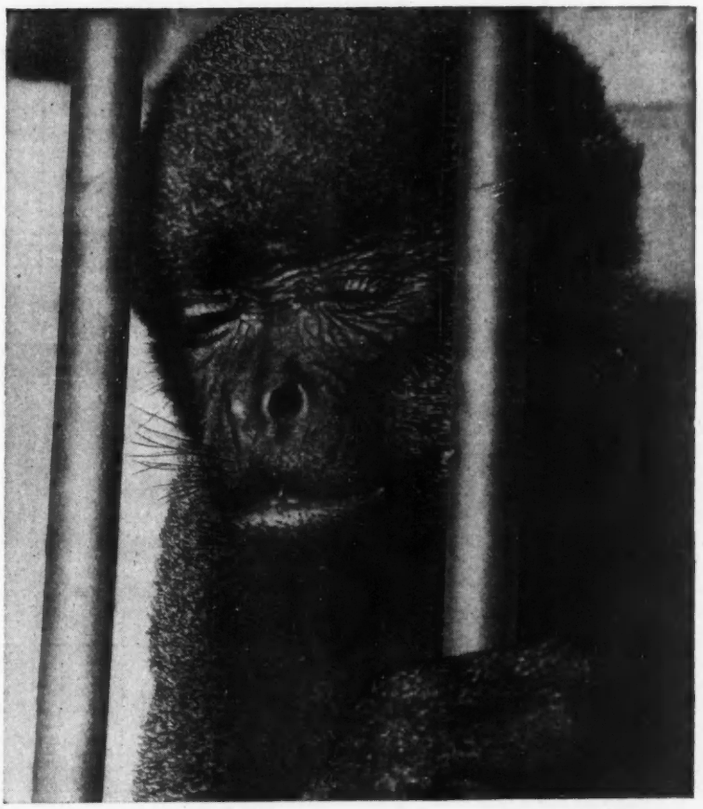

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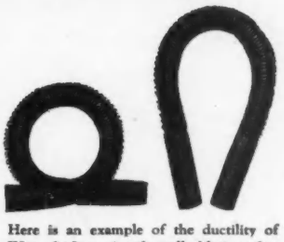

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Stroke	158in.
Max. height under arm ...	57in.
Continuous cutting speeds of table, in both directions 20-240 ft./min.	
H.P. Table drive motor ...	100
Approx. Net weight	42 tons.

A heavy machine with two tool heads on arm, one tool head on upright. Table drive is by Ward-Leonard set.

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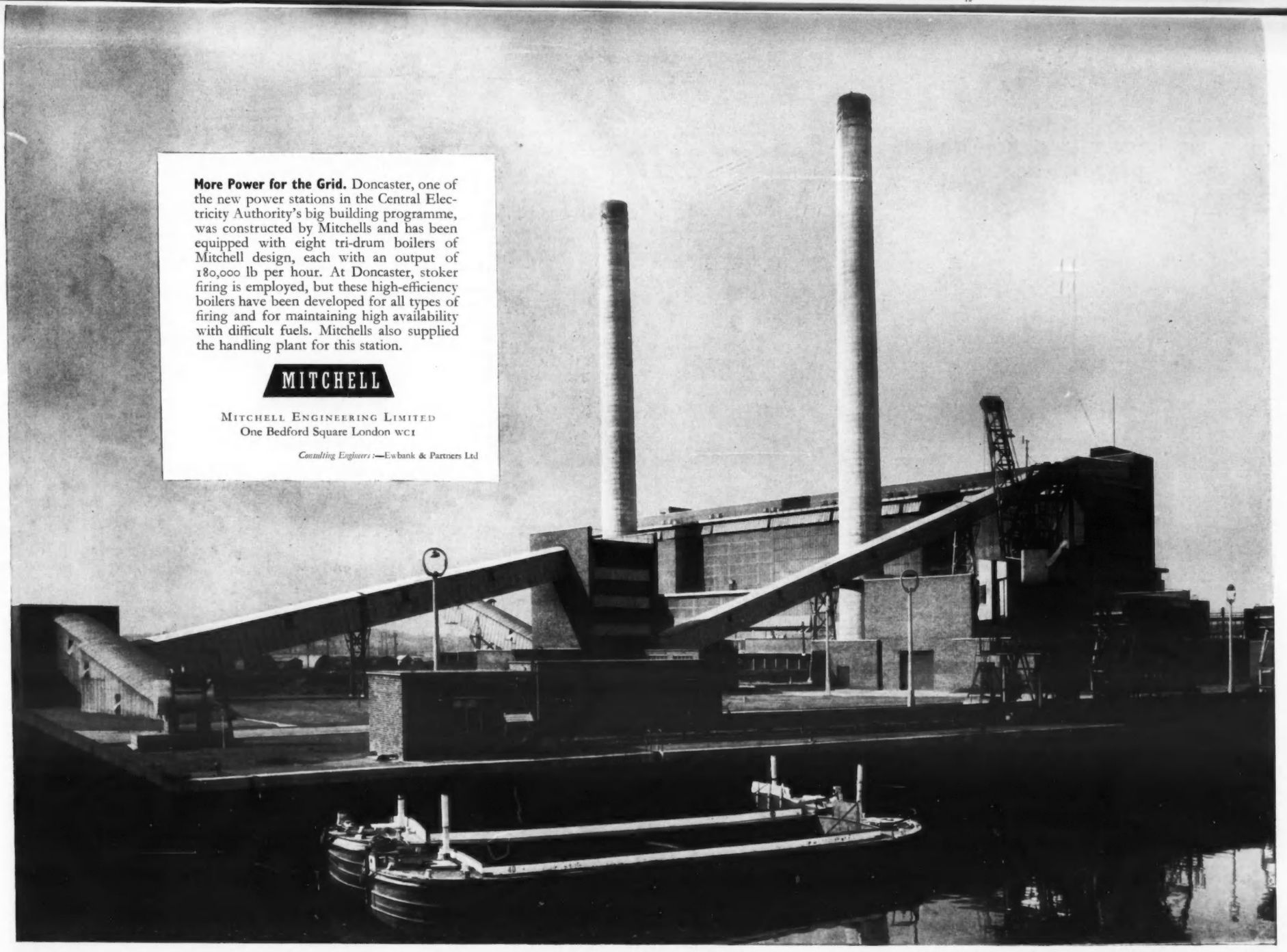

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Atlas Copco produce world's lightest motor drill

From Atlas Copco, the world's largest manufacturers of pneumatic rock-drilling equipment, comes an entirely new motor drill. It is the Atlas Copco *Cobra*, backed by 50 years' experience of rock-drilling equipment, and developed after extensive field tests.

Weighing a mere 53 pounds, the Atlas Copco Cobra is undoubtedly the lightest, handiest motor drill ever brought out. (The usual weight of a motor drill is around 80 pounds.) Yet despite its low weight the Cobra is able to put up a *higher footage* under actual working conditions than other, *heavier* motor drills. It is powerful, robustly constructed and, above all, *100 per cent self-contained!* One man can carry it and start it up *anywhere*.

New exclusive drill features

The Atlas Copco Cobra has 100 per cent air blowing from the built-in compressor. As no exhaust gases are used for clearing the bore-hole, troublesome decarbonizing of the channels to the drilling mechanism is eliminated. Another *first-ever* feature is the free-wheeling mechanism for easier starting and more rapid steel changes. The Cobra also incorporates a unique new method of automatic rotation of the drill chuck, a floatless carburettor enabling drilling up to a 45 degree incline and a pull-type starter. The Cobra drills 100 feet to the gallon, has a drilling rate of 26 feet per hour, and can drill holes up to 13 feet in depth.

The right steels for the Cobra

The Cobra—like all Atlas Copco drills—has been developed for use with *Sandvik Coromant* steels, the world's most widely-used integral drill steels. This, of course, adds considerably to the performance of the Cobra. *No drill or steel developed separately could possibly give such equivalently high results.* Atlas Copco drills fitted with Sandvik Coromant steels have proved an unbeatable drilling unit, responsible for the drilling of no less than one billion feet each year.

World-wide sales and service

The Atlas Copco Group embraces Atlas Copco companies or agents manufacturing or selling and servicing Atlas Copco equipment in ninety countries throughout the world. For further details of the equipment featured here, contact your local Atlas Copco Company or Agent. If you have any difficulty, please write to:—Atlas Copco (Great Britain) Ltd., Beresford Avenue, Wembley, Middlesex, or Atlas Copco AB, Stockholm 1, Sweden.

Motor Drill and Breaker in one!
The Cobra converts to breaker in minutes. Only three small parts to change. Reconversion just as quick.

Easily carried anywhere!
Perfectly-balanced carrying handle. Moulded back frame for transporting cross-country.

Grinder driven from the Cobra!
A specially light drill steel grinder, powered through the crankshaft, can be supplied if required.

THE Atlas Copco GROUP OF COMPANIES

Manufacturers of Stationary and Portable Compressors, Rock-Drilling Equipment, Loaders, Pneumatic Tools and Paint-Spraying Equipment

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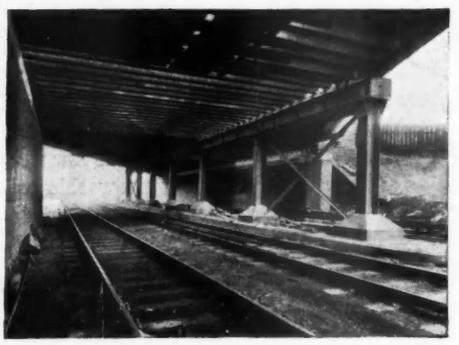

BRIDGE RECONSTRUCTION by BUTTERLEY

Photographs by courtesy of British Railways (London Midland Region)

The three illustrations show the reconstruction and welding of bridge number 75 - Glazebrook to Godley line, carrying the Didsbury Road over the railway for Stockport Corporation, Cheshire. Another example of Butterley bridge reconstruction, carried out with the absolute minimum interference with traffic.

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